THE PLANT DISEASE REPORTER

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THE PLANT DISEASE SURVEY

Division of Mycology and Disease Survey
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THE PLANT DISEASE SURVEY
DIVISION OF MYCOLOGY AND DISEASE SURVEY

Plant Industry Station — Beltsville, Maryland
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BREEDING STRAWBERRIES RESISTANT TO RED CORE ROOT ROT[1]

Robert D. Reid

Historical

During the period of 1921-1930, a hitherto unknown root disease -- later to become known as "Red Core" -- made its appearance and ultimately devastated the strawberry growing industry in south west Scotland. An investigation was initiated by the West of Scotland Agricultural College in 1926, and in 1930 was continued by the Department of Agriculture for Scotland with the active co-operation of the College which in 1933 provided facilities at Auchincruive, near Ayr. In 1951 the strawberry investigation unit became an integral part of the newly formed Scottish Horticultural Research Institute whose headquarters are at Mylnefield, Invergowrie, Dundee, but the unit and the work on Red Core remains located at Auchincruive.

The objectives of the work initiated in Scotland in 1926 were to identify the causal organism and to develop a practical method of control. In 1929 Alcock (1) suggested an unidentified species of Phytophthora as the cause and in 1930 Alcock, Foister and Howells (2) published a full account of the disease and described the pathogen. In 1938, Hickman (3) in England succeeded in isolating the causal organism which he named Phytophthora fragariae Hickman, thus confirming and extending the earlier findings of Alcock et al. Since that time our knowledge of the fungus has been added to by the work of Hickman and Montgomerie, by American workers (4), and by the more recent work summarised in this paper. Attempts to control the disease by either cultural or chemical means failed and efforts were therefore made to secure or breed resistant varieties. A programme of breeding (5) with this objective was started in 1933 and this paper summarises the more important results that have been obtained during the past twenty years.

General Methods and Procedure

An extensive collection of named varieties from all parts of the world as well as several species of Fragaria were tested by growing in heavily infected soil. Most varieties proved to be highly susceptible but a few were moderately or highly resistant. The most promising of these were selfed and the resulting seedlings tested by growing in infected soil. It was found that susceptible varieties produced families almost all of which became infected in the first year, whereas varieties which were known, or afterwards proved to be resistant, in some cases gave families of which at least 50 percent were resistant in the first year of trial. It was evident that the observed resistance was heritable and would therefore provide a proper basis for a breeding programme.

Methods: The procedure which has been evolved as a result of experience over many years is, briefly, as follows:

Pollination is carried out in a glasshouse and seed is sown as soon as convenient after ripening. The seedlings are pricked into boxes and when large enough, usually 8 to 12 months after sowing the seed, they are transplanted into an open field, the soil of which is known to be heavily and uniformly infected with P. fragariae. Individual plants are spaced at one yard apart each way. The runners from each seedling are restricted to about six per plant which are rooted close to the parent. This unit is allowed to remain in position for about two years, and during winter or early spring, runners from each plant group are lifted and the roots examined for infection. Those units which have not become infected and which show some pomological merit are carried forward for further test. All the rest are discarded. The resistant selections carried forward are now planted as four-plant units, again one yard apart each way, and all the runners from the four plants are trained into the interior of the square to form a matted block. These units again occupy the land for two seasons during which they are again examined for Red Core infection. When fruiting their pomological characteristics are recorded, a very exacting standard being applied at this stage. The plants retained are propagated on a larger scale to permit of more extensive pomological and pathological tests.

Virus Testing: At this stage individual plants are transferred to a glasshouse and tested for virus content by stolon-grafting to a suitable indicator. Particular emphasis is placed upon

[1]Paper presented on September 11 at the International Horticultural Congress, held in London, September, 1952.

maintaining a virus-free nucleus of each selection as a stock reserve, as even resistant varieties with promising pomological characters have no commercial future unless we can provide a virus-free stock.

Basic Breeding Material

No. 52: Of the large number of varieties tested only that known as No. 52 showed sufficient resistance to be of interest and it became the foundation of our breeding work. It is believed to have been the obscure variety "Frith", a chance seedling of unknown parentage developed as a local variety in Kent; but the precise identity of No. 52 was never established and the few available plants were so heavily infected with virus diseases that the whole stock was lost within a few years, but not before a good number of its progeny had been obtained. So pronounced was the factor for resistance in No. 52 that when either selfed or crossed with susceptible varieties, the F_1 generations often contained over 50 percent of resistant seedlings. The F_2 families from No. 52 selfed again showed a high proportion of resistant seedlings. The first five Phytophthora resistant varieties introduced to commerce in Scotland under the names Auchincruive 1, 2, 4, 5 and 6 were seedlings obtained from No. 52 selfed. Incidentally the same family provided the selections BK 46, BK 48, BK 52 and CC 18, which have been used successfully by United States workers at Beltsville to incorporate this same line of resistance into their seedlings. The discovery of the resistance of No. 52 can be regarded as the first important step in the fight against Red Core so far as we are concerned in this country.

American Varieties: Anderson (6) in 1935 appears to have been the first United States worker to call attention to the incidence in the United States of a disease resembling Red Core. Within a short time it was reported that Aberdeen, a local Maryland variety -- also of unknown parentage -- was highly resistant to the disease. Dr. Anderson kindly provided us with plants of Aberdeen and its resistance to Red Core under our conditions was confirmed. When selfed, the families obtained contained in many cases 60 to 80 percent of resistant seedlings, and when crossed with the progeny of our No. 52 gave a wider variation, ranging from less than 50 to over 90 percent resistance. The variety Auchincruive Climax is one of a family obtained by crossing an F_2 seedling from No. 52 with Aberdeen. Obtaining the resistant American variety Aberdeen and its use by us from 1938 onwards marks the second important stage in our breeding work.

By 1945 both our small unit at Auchincruive and the much larger units in the United States, particularly that at Beltsville, had a large number of seedlings showing different degrees of resistance and of widely varying pomological characters. An exchange of material was effected with Dr. G. M. Darrow whereby we received the following selections from Beltsville: -- Temple, Fairland, U.S. 3203, 3328, 3378; and from New Jersey: -- Pathfinder, Sparkle, N.J. 380, 1051, 1074, 947, and 943, all of which were reputed to be resistant to Red Core. Under our conditions, some proved completely susceptible, others highly resistant. All of these American varieties so far received were infected by virus diseases and none produced fruit of a type likely to be acceptable in our markets. In most cases the weight of crop produced was also very low.

Other Sources of Resistance

The variety Little Scarlet (believed to be a form of F. virginiana) when crossed with Aberdeen gave a very high proportion of resistant seedlings, most of which proved to have very small, and all of which had very soft textured fruits. The best of these, when selfed or crossed, showed that this intensification of resistance persisted in the F_2 and F_3 generations but that the linkage with unsatisfactory fruiting characters continued. Some of the small fruited types gave families of which over 90 percent were resistant whereas with some of the larger fruited types, resistance fell below 50 percent.

The more recently introduced variety Perle de Prague in some cases proved highly resistant under field conditions whereas under other circumstances it readily became infected. It has therefore been used in the more recent breeding work but it is as yet too early to assess the few results so far available. In one cross with Aberdeen none of the progeny proved to be resistant but when crossed with Climax and with certain other resistant selections over 60 percent of the progeny were resistant.

Several other reputedly resistant varieties have been tried without success and the main breeding programme has been based on the above mentioned varieties. We have combined them in many ways, often on a purely empirical basis, our main objective being to obtain in one plant

a sufficient degree of resistance to all the known strains of Phytophthora fragariae to give us one variety which can be planted under a wide range of conditions.

Effect of Parentage

As the objective of the work was the production of varieties suitable for introduction to commerce, unsuitable types are discarded at the earliest opportunity irrespective of the cause. Exact data on inheritance cannot therefore be given. Comparison of numbers of seedlings infected in different years can be misleading since the degree of Red Core infection varies in different years in accordance with variations in the rainfall. The proportion to become infected during the first year of test provides a useful comparison between different families in a given year, but failure to become infected in the first year does not necessarily indicate immunity, a (usually) decreasing proportion becoming infected in succeeding years. Other factors, pathological or physiological, lead to the loss of many plants before their Red Core susceptibility can be assessed. Under this head may be included: winter deaths from causes not always ascertained, plants killed by root eating pests, plants discarded because of visible symptoms of virus infection or obviously high susceptibility to common diseases or pests.

By the second summer unsatisfactory fruiting types are discarded and thereafter there is a progressive discarding for various reasons over a number of years.

This necessity to discard for a variety of reasons, over a prolonged period, which is so essential in plant breeding is not always appreciated by the student of genetics who is apt to over-simplify the issue by considering a small number of factors. I have not space to deal with the 650 families which have been raised in the course of this work, but in Table 1 and in Figure 1 there is shown in eight representative families the progressive rate at which seedlings have been discarded over a four-year period for three different causes: --1. Red Core Susceptibility; 2. Other Pathological Causes; and 3. Unsatisfactory Fruiting Characters.

The figures in the last column as "retained" applied to those which were selected as having a high degree of disease resistance, an inherent vigour which enabled them to withstand the ordinary risks of other pathological or physiological troubles, and which gave sufficient evidence of pomological merit to justify their being tested more extensively.

This infinitesimally small number of selections available after four years' intensive testing, when subjected to further re-selection may possibly yield one or two which give promise of being worthy of consideration for development as commercial varieties. More likely, however, previously unsuspected weaknesses will become evident, frequently a lack of adaptability to the normal year to year changes in climate. Many selections give a good performance in one year when all environmental conditions are exactly suitable but unless a variety can be depended upon to give a consistently good performance year after year and under a fairly wide range of soil conditions its chances of becoming an established commercial variety are slight.

From this table certain general trends may be seen. In families incorporating one susceptible variety (e.g. LR 19) in their parentage about 50 percent usually succumb to Red Core within the first two years of test and there is a continuing appearance of Red Core in succeeding years amongst the survivors.

Where two resistant varieties have been crossed (e.g. Climax, Aberdeen, and some of the Beltsville selections) the initial incidence of Red Core is lower, rarely exceeding 30 percent in the first two years of test.

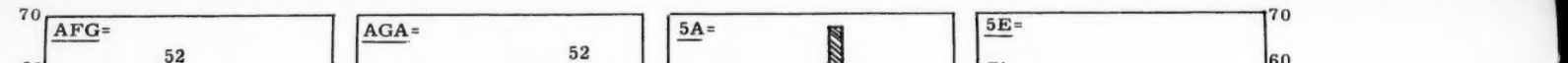
When the Little Scarlet factor is introduced (family ABP) there is a very low incidence of Red Core in the first two years. This is accompanied by a remarkably large proportion discarded in the first two years for unsatisfactory fruiting characters, showing there is little difficulty in deciding upon their lack of pomological merit, which is usually indicated by small and very soft fruits.

Crosses incorporating certain of the Beltsville selections produced large proportions of seedlings with no pomological merit. In this case the fruit is usually quite large but soft in texture and the crop is light.

In all strawberry breeding, even when disease resistance is not a factor, the proportion of seedlings possessing sufficient merit to justify their commercial introduction is exceedingly small. Because of the very few unrelated sources of resistance available to us the production of varieties which combine resistance, good fruit quality and high yielding capacity has not been easy nor is it likely to be. The United States selections which utilise the same sources of resistance available to ourselves have neither cropped sufficiently heavily nor yielded fruit acceptable under ordinary commercial standards in this country --no doubt owing to the difference in climate, but also in part because of the different requirements of our respective markets.

Table 1. Strawberry breeding: Proportions of seedlings discarded. Progressive rate of discarding in eight representative families.

Index	Cross	Number in family	Percent discarded												Percent retained
			Red core				Other reasons				Fruiting				
			1st Year	2nd Year	3rd Year	4th Year	1st Year	2nd Year	3rd Year	4th Year	1st Year	2nd Year	3rd Year	4th Year	
AFG	LR 19 x Aberdeen	84	42.8	2.4	2.4	11.9	15.5	1.2	--	--	20.2	1.2	1.2	--	--
AGA	Climax x Aberdeen	110	2.7	4.5	0.9	--	17.3	17.3	--	--	23.6	9.1	21.8	0.9	0.9
5A	Aberdeen x ABP 13	183	--	5.5	4.9	--	--	8.7	10.4	--	67.8	--	2.2	0.5	--
5E	Climax x Self	390	23.1	6.9	5.6	0.5	11.8	2.3	--	--	38.7	0.5	7.4	2.0	1.0
6B	Temple x Climax	217	21.7	12.5	2.8	0.5	3.7	--	--	--	54.4	0.5	2.8	0.5	0.9
6R	10 x Climax	104	8.7	21.2	--	--	9.6	4.8	5.8	1.9	35.6	5.8	1.9	--	4.8
6G	U.S. 3203 x Climax	131	17.6	12.2	0.8	--	0.8	5.3	0.8	--	42.7	3.1	16.8	--	--
6K	U.S. 3203 x Self	220	23.6	1.8	--	--	1.4	--	--	--	70.9	--	2.3	--	--



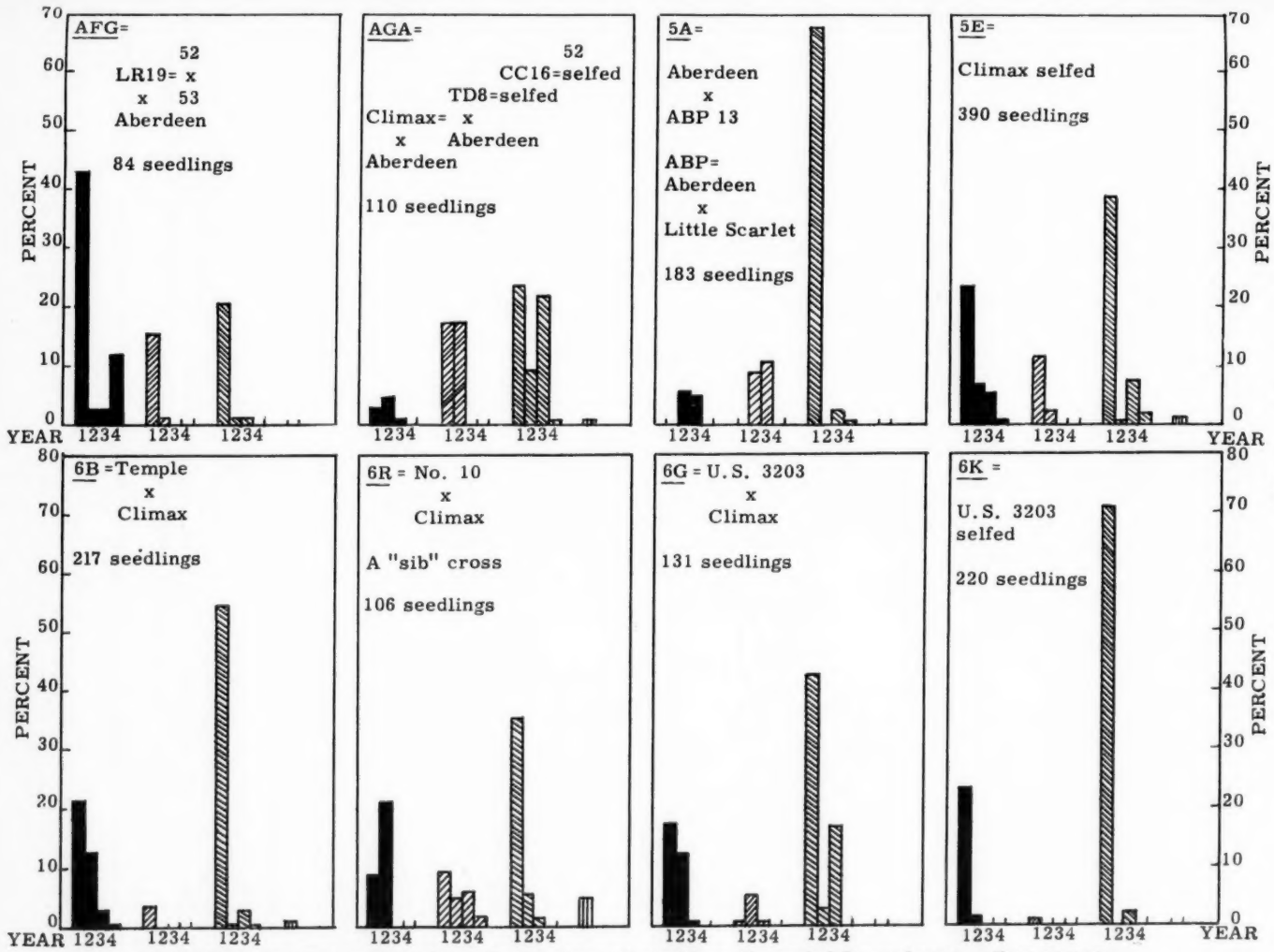


FIGURE 1. Strawberry breeding: Proportions of seedlings discarded for red core, other causes, and unsatisfactory fruiting, and percent retained, in eight representative families over four-year periods. (See also Table 1.)

Table 2. Red core disease of the strawberry: Resistance of varieties to different strains of Phytophthora fragariae. Comparison of results[a] obtained by Montgomerie (I in table)[b] and by Hickman and English (II)[c] using pure cultures, and by Reid (III), with natural inoculum

Source of inoculum	Indicator varieties															
	Huxley			Oberschlesien			Climax			Perle de Prague			Auchincruive 11			Auchincruive 6		
	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III	I	II	III
HUXLEY																		
1. ex Lothians Pure Culture	S			S			R						R			R		
2. ex Kent Isolate 107		S						R			R							
3. ex Natural Inoculum									R						R			
4. ex Nat. Inoc. ex Isol. 81									R			R			R			
5. Nat. Inoc. ex Ireland									R			R			R			
SOVEREIGN																		
1. Pure Culture	S			S			R						R			SL		
AUCHINCRUIVE 1																		
1. Pure Culture	S			S			R						R			S		
2. Natural Inoculum									R						R			
3. Nat. Inoc. ex Isol. 91									R			R			R			
AUCHINCRUIVE 5																		
1. Pure Culture	S			S			R						R			S		
2. Pure Culture Isol. R4		S						R			S							
3. Pure Culture Isol. R1		S						R			S							
CLIMAX																		
1. Pure Culture	S			S			S						SL			S		
2. Pure Culture Isol. R6		S						R			S							
3. Pure Culture Isol. R11		S						S			SL							
4. Pure Culture Isol. R12		S						S			SL							
5. Natural Inoculum									S			R			R			SL
6. Nat. Inoc. ex Isol. 74									S			S			R			
7. Natural Inoculum									S			R			R			
AUCHINCRUIVE 2																		
1. Pure Culture	S			S			R						R			S		
MME. LEFEBVRE																		
Pure Culture																		
Isol. 104 ex Cornwall		S						R			SL							
(VAR. UNSPECIFIED)																		
Pure Culture																		
Isol.105 ex Scotland		S						R			S							

[a] S=susceptible R=resistant SL=slight infection

[b] Miss I. G. Montgomerie, Plant Pathology Laboratory, Department of Agriculture for Scotland. Private communication.

[c] Dr. C. J. Hickman and Miss Mary P. English. Trans. Brit. Mycol. Soc., Vol. 34, Pt. 3, 1951

Table 3. Red core disease of the strawberry: Resistance of varieties to different strains of Phytophthora fragariae. Summary of results[a] (by Reid) using natural inoculum (infected roots) from different sources.

Indicator variety	Source of inoculum: 1948-51: Climax (ex Lanarkshire)	Auchincruive 1 (ex Lanarkshire)	Huxley (ex Lothians)	LR 19 (ex Lanarkshire)	Ruskin (ex Lanarkshire)	8C (ex Auchincruive)	1951-52: Isolate 74[b] ex Climax	Isolate 81[b] ex Huxley	Isolate 91[b] ex Auchincruive 1	Huxley (ex Northern Ireland)	Climax (ex Lanarkshire)	AES 23 (ex Auchincruive)
Fairland (ex Beltsville)	S			R								
Temple (ex Beltsville)	R			R								
U.S. 3203 (ex Beltsville)	S			R								
Early Cambridge	S			SL								
Tree Ettisburg (ex Tasmania)	S			R								
Auchincruive 1	R											
Auchincruive 2	R											
Auchincruive 4	S											
Auchincruive 5	SL											
"Corntown" (unnamed var. from North of Scotland)	SL			S			S	S	R	S	S	S
Aberdeen	R						R	R	R	R	R	R
Perle de Prague	R			S			S	R	R	R	R	R
Climax	S	R	R	R	R		S	R	R	R	S	S
Fragaria vesca	S		S	S	S	S	SL	S	S	S	S	S
Seedlings:												
Auchincruive 11	R	R	R	R			R	R	R	R	R	R
AES 23	S		R				R	R	R	R	S	S
AES 146	R	R	R			R	S	R	R	R	R	R
5F 80	S	SL	R			R	S	R	R	R	R	S
6A 6							S	R	R	R	S	R
6J 4	R	R	R			R	S	R	R	R	R	
6J 27	S						R	R	S	R	S	R
5E 370							S	R	R	R	R	S
5V 162							S	R	R	R	R	R
5V 322							S	R	R	R	R	R
5V 177	R											
5C 32	R											
6H 70	S											
6J 92	S											
6J 194	S	R	R									

[a]R=resistant S=susceptible SL=slight infection

[b]Isolates 74, 81, and 91 were supplied by Miss Montgomerie as pure cultures. These were used to infect F. vesca, the roots of which were subsequently used as natural inoculum.

Table 4. Parentage of varieties and seedlings included in Tables 1, 2, and 3.

Variety or seedling	Parentage
LR 19	No. 52 (believed to be "Frith") X No. 353 (seedling of unknown parentage)
Climax	TD 8 = (CC 16 x Self = No. 52 x Self) X Aberdeen
No. 10	Seedling from same cross as Climax
ABP	Aberdeen X Little Scarlet
Temple Fairland U. S. 3203 U. S. 3328 U. S. 3378	Seedlings raised at Beltsville, Maryland = Aberdeen x Fairfax
N. J. series	Raised in New Jersey
Auchincruive 11	Aberdeen open pollination
Corntown	Unknown variety from North of Scotland reputed resistant
Early Cambridge	Raised at Cambridge, reported to be Sovereign x Ekey
Tree Ettisburg	Received from Tasmania
AES	AEA = LR 19 X X Aberdeen ADD = ZL 259 = No. 52 X X Aberdeen PU = No. 52 X Fragaria chiloensis
5F	U. S. 3328 x Self
6A	Fairland x Climax
6J	N. J. 1051 x Climax
5E	Climax x Self
5V	No. 10 x Self
5C	Aberdeen x Climax
6H	U. S. 3378 x Self
Auchincruive 1, 2, 4, 5, and 6	No. 52 x Self

The production of Climax, which combines resistance with heavy yields of good quality fruits, at such an early stage in the work was most fortunate, and the influence of this variety on fruit quality in more recent seedlings has been marked. As will be shown later however the resistance is by no means complete.

Loss or Breakdown of Resistance

It was observed quite early in these investigations that resistance to infection by a particular variety was not absolute. It was found that a variety, after maintaining complete resistance for a number of years, would, under certain conditions, become severely infected. Resistant varieties, when grown under commercial conditions, also occasionally become infected. In the latter case, infection invariably began as small isolated areas in an otherwise clean field. Sometimes these areas remained very much localised; sometimes the infected area underwent rapid enlargement. When clean plants of the same resistant variety were planted in these "breakdown" areas, they too, became rapidly infected.

Experiments with plants growing in pots in the greenhouse showed that inoculum in the shape of pieces of infected root taken from a normally resistant plant, growing in a breakdown area, readily infected clean plants of the same variety. Such plants were, however, still resistant to inoculum taken from "ordinary" sources. These observations, made four or five years ago, led to the conclusion that there were a number of strains of the fungus Phytophthora fragariae with special host relationships. American workers, Hickman, and Montgomerie (private communication) using the pure culture technique, have now shown that there are in fact these specialised races of the fungus. In consequence, the breeding work which twenty years ago was conceived as a simple problem of producing varieties resistant to a particular fungus now becomes much more complex and difficult.

The high degree of specialisation to be found in these strains and the relative ease with which they may arise in the future is of considerable practical importance. American workers (7) already recognise two strains. Hickman (8) has shown from pathogenicity tests that three groups appear to exist while we think we have evidence for many more. The ordinary strain, for example, which infects Huxley does not infect Climax or other resistant varieties. A strain may infect Huxley and certain other resistant varieties but does not infect Climax. Thirdly a strain which infects Climax also infects Huxley but does not infect certain other resistant varieties. In our experience all strains will infect the non-resistant varieties.

Table 2 shows the results obtained, by Hickman and English using pure cultures of strains of the pathogen on three varieties, by Montgomerie (private communication) using pure cultures of six strains on five varieties, and by Reid using natural inoculum from various sources on some of the same varieties used by these other workers. It will be seen that with a very few exceptions, the results are in agreement.

Table 3 shows the results of a more extended series of trials (by Reid) using natural inoculum from twelve sources on a number of varieties, mainly new seedling selections. These results appear to support the view that there is a large number of strains and that up to the present no variety or selection, when exposed to infection by every strain, is completely resistant to all. Under field conditions many selections have however not yet become infected.

Discussion and Conclusions

Strawberry breeding has been carried out since 1933 with the definite objective of raising new varieties resistant to Red Core root rot (Phytophthora fragariae), having fruiting characters acceptable to commercial fruitgrowers, and free from infection by the virus diseases. Over 650 families comprising approximately 60,000 seedlings have been raised and field tested. Several thousands are still under test and it is confidently hoped that a few of these may be found suitable for introduction to commerce. Past introductions consisted of five varieties which were introduced as an interim measure to maintain the local industry in being. These after having served a useful purpose for seven or eight years have been allowed to pass out of cultivation as they were replaced by a better variety.

The only named variety so far introduced is Auchincruive Climax, which was produced from a cross made in 1939, released to commerce in 1947, and has already proved to be the outstanding introduction of the last fifty years. In Scotland it is practically the only variety grown extensively on a commercial scale and in England and Ireland it already occupies a greater area than all other varieties combined (9).

Very few genetically distinct sources of resistance have been found. The two most important are our No. 52 (believed to have been Frith) and the American variety Aberdeen. Other

and more recently discovered sources of resistance are being tried but it is too early to assess results. Pure species have not helped but the variety Little Scarlet, generally considered to be a form of F. virginiana appears to increase resistance.

It has been found that there are now several physiological strains of the pathogen, some of which will attack Climax. The limited observations which have so far been possible lead us to conclude that, given the proper sequence of circumstances, new physiological strains can develop de novo in any soil already heavily infested with the fungus. It is also possible for the organism to be conveyed from one locality to another by soil and especially by infected plants.

Red Core disease is now known to be distributed throughout many different countries as well as the United Kingdom and constitutes a grave menace to the strawberry growing industry. To keep it under control requires vigorous action by research workers, administrative bodies, and growers alike. The work of the plant breeder must be extended particularly in the direction of discovering new genetical sources of resistance. Much can be done to prevent new land becoming infected either with the already widespread existing strains of the pathogen, or by the newly produced physiological races. The most important step is to avoid distributing infected plants; secondly to avoid replanting infected land and whenever the disease does make its appearance to localise the outbreak.

By the use of such measures, with the help of resistant varieties, many growers who ten years ago were unable to grow strawberries, are now able to keep the disease within reasonable bounds and are growing satisfactory crops.

SUMMARY

Strawberry breeding has been carried out since 1933 by the Department of Agriculture for Scotland with the collaboration of the West of Scotland Agricultural College, at Auchincruive, near Ayr. The objectives have been the production of varieties resistant to Red Core Root Rot (Phytophthora fragariae Hickman), with fruiting characters acceptable to commercial growers, and to develop them free from other diseases. Very high resistance is obtained but new strains of the causal organism attack previously resistant varieties. The main sources of resistance have been No. 52 (believed to be Frith) and the American variety Aberdeen. Other sources have been used more recently. Pure species have not helped but Little Scarlet, generally considered a form of Fragaria virginiana appears to increase resistance. Inheritance of resistance is estimated on the proportion of seedlings to become infected in the first year of exposure to natural inoculum in infected soils. Susceptible varieties yield families of which 100 percent are susceptible while resistant types may show less than 20 percent susceptibility under similar conditions. A few varieties were released early in the work as a temporary expedient for local use but the main introduction up to date is the variety Auchincruive Climax now of very considerable importance throughout the British Isles.

RÉSUMÉ

L'amélioration des framboisiers a été entreprise depuis 1933 par le Département d'Agriculture d'Ecosse avec la collaboration du Collège Agricole de l'Ouest de l'Ecosse à Auchincruive, près de Ayr.

Le but a été la production de variétés résistantes à la pourriture "red core" (Phytophtora fragariae Hickman), possédant des caractères du fruit acceptables pour la vente, ainsi que la multiplication de ces variétés à l'abri des autres maladies.

Une très haute résistance a été obtenue, mais de nouvelles races de l'organisme pathogène attaquent les variétés précédemment résistantes. Les sources principales de résistance ont été le No. 52 (que l'on croyait être le "Firth"), et la variété américaine "Aberdeen". D'autres sources ont été employees plus récemment. Les espèces pures n'ont pas été employées, sauf "Little Scarlet", considérée généralement comme une forme de Fragaria virginiana et qui semble accroître la résistance. L'hérédite de la résistance est estimée d'après la proportion des jeunes plantes qui deviennent infectées la première année de leur exposition dans un sol infecte par l'agent pathogène. Les variétés sensibles engendrent des familles dans lesquelles 100 pour-cent sont sensibles, tandis que les types résistants peuvent en produire moins de 20 pour-cent dans les mêmes conditions. Un petit nombre de variétés furent employees dans les premières années de ce travail comme un expédient temporaire pour des besoins locaux; mais la principale et la meilleure introduction à ce jour est la variété "Auchincruive Climax" qui a acquis maintenant une importance considérable dans les Iles Britanniques.

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SCOTTISH HORTICULTURAL RESEARCH INSTITUTE

STRAWBERRY STUNT VIRUS IN FRAGARIA VESCA[1]

R. L. Skiles and T. H. King

Near Duluth, Minnesota, in the summer of 1951, some Robinson strawberry plants were found that were much smaller than other plants of the same variety growing adjacent to them. The stolons and petioles were very short and the leaflets were only one-third to one-fourth of normal size. There was considerable crown proliferation and upward cupping of the older leaflets on the mother plants and all runner plants. One of the diseased plants and its runners was moved to the greenhouse at University Farm, Saint Paul, Minnesota, where, after several months, the leaflet cupping more or less disappeared and was replaced by marginal chlorosis. At no time was the foliage mottled or crinkled. The runner plants rooted very slowly but all plants flowered readily. It is believed that the plant was infected with the stunt virus described by Zeller and Weaver (5).

Five plants of Fragaria vesca (East Malling clone) were grafted to the Robinson plant at different times. The stolons of the infected plant were old and woody, but the indicator plants were inarch grafted stolon-to-stolon because the Robinson petioles were too frail to permit stolon-to-petiole grafts. In each case an organic union resulted and each F. vesca plant developed identical symptoms. The first, and very marked, symptom was marginal chlorosis of the older leaves. This was accompanied by slight crinkling of the leaflets and spreading of the affected leaves into a horizontal position. Leaves emerging after the appearance of the primary symptom were epinastic, asymmetrical, considerably reduced in leaflet size and petiole length, slightly crinkled, and slightly chlorotic, with the chlorosis more concentrated around the leaflet margins. Three or four weeks later the emerging leaves were similarly dwarfed and chlorotic but were erect instead of epinastic. Two to four weeks after the initial symptoms became apparent the older leaves died, leaving finally a dense group of erect, dwarfed leaves (Fig. 1). This appears to be the last stage of symptom development as all the infected F. vesca plants are now about six months old and no new symptoms have appeared. Individual leaflets are one-sixteenth to one-fourth inch long and the petioles are one-half to one inch long. There is considerable crown proliferation and the plants have never formed stolons or flowered.

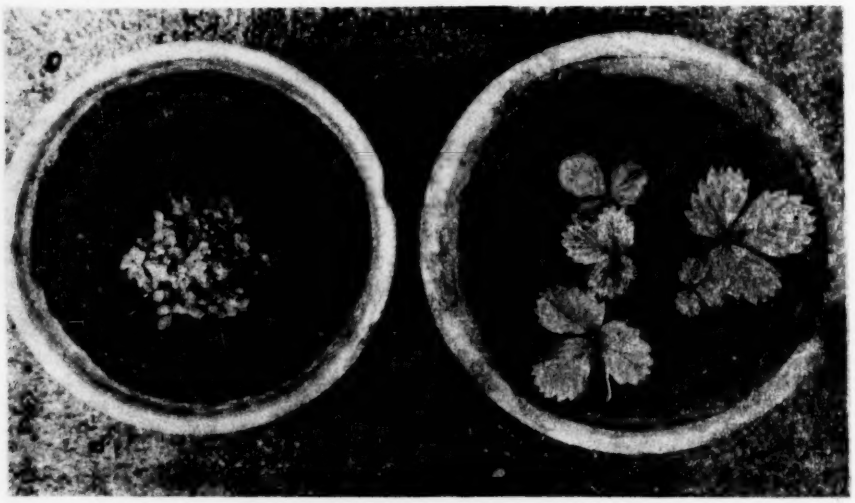

FIGURE 1. Stunt virus in Fragaria vesca. Virus-free plant on the right. The virosed plant is in the last stage of symptom development.

The general pattern of symptom development of the stunt disease in F. vesca follows the patterns of other described virus diseases in this indicator (1, 2, 3, 4). Comparisons were made between F. vesca plants infected with stunt virus from Robinson, yellows virus from Marshall variety (type 1 virus Demaree and Marcus), and type 2 virus Demaree and Marcus from Wiscon-

[1]Scientific Journal Series Paper No. 2906, Minnesota Agricultural Experiment Station.

sin 537 variety. The symptoms of the three were easily distinguishable either in their developmental or final stages. Stunt differed from yellows in that the primary symptom of the latter was severe chlorotic spotting of the leaflets; no spotting was evident on plants with stunt. The final stage of infection by the stunt virus differed from type 2 virus in that the latter did not cause the severe dwarfing that characterized the former. The virus from Robinson appears to be similar to the type 3 virus described by Demaree and Marcus (1, 2) because it induces severe dwarfing; dissimilar, however, in that type 3 causes chlorotic spotting of the leaflets. Mixtures of virus-types 1 and 2 are also different from stunt in respect to the formation of mottled or spotted leaves.

The stunt disease appears to be a relatively uncommon one that has been known only by its symptoms on commercial varieties. From the evidence presented it seems probable that the disease is distinct etiologically from other diseases produced by known viruses or virus combinations in strawberries.

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TERMINAL BUD AND SHOOT INFECTIONS AND THE OVERWINTERING OF XANTHOMONAS PRUNI IN PEACH TREES

M. C. Goldsworthy and R. A. Wilson[1]

In connection with field spraying experiments for the control of the peach bacterial spot organism (Xanthomonas pruni) in orchards along the Atlantic seaboard, the writers encountered numerous instances of its overwintering in diseased terminal buds and shoots. These diseased buds and shoots are clearly visible in late winter before the new leaves unfold, and pure cultures of X. pruni have been isolated from them. Sometimes only the terminal bud is involved. More frequently the diseased condition, named for convenience "black tip", occurs also on a varying number of lateral buds and associated cortical tissues below the apex.

These black tips obviously harbor masses of overwintering X. pruni, but the time when infections occur cannot be determined from field specimens collected in late winter. Accordingly, it seemed desirable to produce the black tip condition with pure cultures of X. pruni and demonstrate overwintering of the bacteria under experimental conditions.

Fifty one-year-old Elberta peach trees were potted and brought into a greenhouse at Plant Industry Station, Beltsville, Maryland. The trees had a few leaves on the lateral and terminal shoots. These leaves were removed and on October 25, 1949, the terminal buds on all the shoots of 40 trees were covered with cotton saturated with an aqueous suspension of X. pruni. The terminal buds of 10 trees were covered with cotton saturated with distilled water. Except for possible openings made by the removal of the leaves, the buds and adjacent twigs were not punctured or otherwise injured. All 50 trees were kept in a humidity chamber for one week and then placed outdoors to overwinter.

On January 26, 1950, 93 days after trees were inoculated, a number of the terminal buds and the adjacent twig tissues were darker in color on the inoculated trees than on those that had been treated with distilled water only. This discoloration of the terminals continued to progress and on May 1, 1950, as much as five inches of the apex of some of the shoots was definitely blackened and diseased. Isolations from these diseased terminals produced typical X. pruni cultures. On May 4 aqueous suspensions of the bacteria from these cultures were sprayed on the leaves of Sunhigh peach trees. Typical bacterial spot symptoms appeared on May 11.

The experiment was repeated on October 23, 1950, by inoculating the terminal buds of 11 trees of Elberta and 10 of Sunhigh variety. The trees, with the terminal buds covered with cotton saturated with a bacterial suspension, were kept in a humidity chamber for 10 days and then placed outdoors to overwinter. The first signs of infection were noted on February 5, 1951, 105 days after the terminal shoots were inoculated. On April 9, 1951, 168 days after the inoculation, 6 percent of the Elberta shoots and 21 percent of the Sunhigh shoots were diseased. Two of the shoots developed the black tip condition for a distance of 12 inches from the apex. The black tip condition did not develop on any of the shoots treated with distilled water only.

The experiments of 1950 and 1951 prove that X. pruni does overwinter in twigs inoculated the preceding fall. The presence of the organism in the twig tissues was demonstrated by isolation experiments in the spring of 1950 and by the development of natural infections on leaves adjacent to the infected twigs in the spring of 1951.

Although the bacteria were placed in contact with the shoots on October 25, 1949, and October 23, 1950, visible signs of infection, i.e., black tips, did not appear until January 26, 1950, and February 5, 1951, after an interval of more than 90 days, but before any of the leaf buds had unfolded. The black tips are similar to the infections called "spring canker" by Thornberry and Anderson (2). In fact they depict in Figure 3 of their paper a shoot that the present writers would call black tip. Furthermore, they stated that the time of twig infection is "... probably during rains before the infected leaves drop in the fall ... [and that] ... only late infections that occur shortly before the rest period of the host tissue starts constitute the source of canker bacteria the following spring ..."

In short, the spring cankers of Thornberry and Anderson are the result of twig infections the previous fall, and the present writers have shown that the black tip condition of the terminal buds and shoots is likewise the result of infections the previous fall. It would seem, therefore, that terms "spring cankers" and "black tip" would be synonomous were it not for the fact that symptoms appear later in the season under Illinois conditions than along the Atlantic seaboard. This difference in time of development of symptoms may be due, as Hopperstead and

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[1] M. C. Goldsworthy was formerly senior pathologist; R. A. Wilson is biological aid; Bureau of Plant Industry, Soils, and Agricultural Engineering.

Manns (1) suggested, to the more humid, milder winter climate of the seaboard area. However, because the symptoms can be observed while the trees are still dormant, the writers prefer the term "black tip" rather than "spring cankers" to designate the condition prevalent in Atlantic seaboard orchards.

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FROG-EYE LEAF SPOT (BLACK ROT) CONTROL UNDER EPIPHYTOTIC CONDITIONS[1]

P. L. Poulos and J. W. Heuberger

A case of severe defoliation in 1950 in a young Lodi apple orchard at Bridgeville, Delaware, caused by the apple black rot fungus (Physalospora obtusa), was reported by Dunegan and Heuberger (1). This serious outbreak of frog-eye leaf spot was attributed directly to the failure of the grower to remove the dead branches. The previous year, 1949, this orchard had been severely damaged by fire blight (Erwinia amylovora) and the black rot fungus invaded the blighted twigs and branches, thus creating many centers of inoculum potential.

The above cited case of the relation of the frog-eye leaf spot phase of the black rot disease to the fire blight disease on apple is only one of several. The first to indicate this relationship were Scott and Rorer (2) who, in 1908, reported that the causal organism of the black rot disease occurs abundantly on dead apple twigs and branches.

During 1952, a block of Starr apples, at Bridgeville, Delaware, was selected, primarily, for a fungicide spray experiment on control of the fire blight disease. This block was chosen for three reasons: (a) it had been damaged for the past five years by the fire blight disease; (b) the frog-eye leaf spot phase of the black rot disease had been present to some extent in 1951; and (c) the orchardist had failed to do any removal of dead wood for several years. Thus, the inoculum potential for both the fire blight and black rot diseases was such that infection could be serious if weather conditions proved favorable -- such proved to be the case and both diseases became epiphytotic.

Table 1. Frog-eye leaf spot control, Starr variety, Bridgeville, Delaware, 1952.

Treatment	Concentration (ppm)	Disease index (average)
Untreated	-----	6.4
Thiolutin	120	3.4
	60	6.2
	30	6.0
Terramycin	120	4.9
	60	4.6
	30	8.0
Streptomycin sulfate	120	6.3
	60	5.9
	30	6.2
Copper Rimocidin	120	4.7
	60	7.2
	30	6.6
Parzate	2500*	2.1
Dithane Z-78	2500*	3.2
Manzate	2500*	4.0
LSD @ 5%		2.7

* Used at rate of 2 pounds per 100 gallons of water

It is the purpose of this preliminary report to present data on the control of the frog-eye spot phase of the black rot disease. No data are available on the control of the fruit rot phase, or on phytotoxicity to fruit, as there was no set of fruit in the block owing to six days of continuous rain during the blossom period. The data on fire blight control will be presented in a subsequent paper.

Experimentation and Results

Several antibiotics and three ethylene bis dithiocarbamate compounds (Table 1) were applied to single-tree plots, replicated four times and randomized. All were used as sprays and were applied with an orchard sprayer, employing 450 pounds pressure, and using a 5-nozzle boom.

The first fungicide application was made on April 22 at the full pink to early bloom stage of blossom development. The next day, April 23, optimum conditions for the dissemination of, and infection by, the black rot fungus commenced. Rain fell almost continuously for the period April 23 to 29, inclusive, and totalled 3.33 inches. Subsequent spray applications were made on April 30 (near the end of the full bloom stage), May 7 (late petal fall stage), May 19 (first cover stage), and June 4 (late second cover stage).

Frog-eye leaf spot infection was first observed on May 4. Control data were taken on May 9, 16, 26, and 29, the trees being scored on an index ba-

[1]Published as Contribution No. 50 of the Department of Plant Pathology with the approval of the Director of the Delaware Agricultural Experiment Station.

sis of 0 (no infection) to 10 (100 percent infection). The average index for the four scoring dates is presented in Table 1. These data show that three materials -- Parzate (2500 ppm.), Dithane Z-78 (2500 ppm.), and Thiolutin (120 ppm.) -- gave statistically significant control over the untreated at the 5 percent level.

None of the materials used showed any noticeable phytotoxicity to the foliage.

As soon as it was observed that certain materials were giving control of frog-eye leaf spot infection, a block of bearing young Lodi trees in the same orchard was sprayed by the grower with Fermate (2-100), Dithane Z-78 (2-100), and Dithane D-14 plus ferric sulfate (2 qts. - 1 lb. - 100) to obtain information on possible fruit phytotoxicity, if any; the antibiotic Thiolutin was not available in sufficient quantity for use in this work. Three applications were made, namely: approximately at the late petal fall stage, first cover stage, and second cover stage. Examination of the fruit, at harvest, showed considerable russeting from Dithane D-14 plus ferric sulfate, some skin roughening from Fermate, and no phytotoxicity from Dithane Z-78.

Summation

Preliminary control data, obtained under epiphytotic conditions, indicate that two zinc ethylene bis dithiocarbamate compounds (Parzate and Dithane Z-78) and the antibiotic Thiolutin were effective in the control of the frog-eye leaf spot phase of the black rot disease of apple on the Starr variety.

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DEPARTMENT OF PLANT PATHOLOGY, DELAWARE AGRICULTURAL EXPERIMENT STATION

THE RELATIONSHIP BETWEEN FIRE BLIGHT AND APPLE BLACK ROT IN NORTH GEORGIA ORCHARDS

Jack Taylor

During the season of 1952 there was a very marked relationship between the degree of fire blight and the later development of black rot on apple fruits. This spring an epiphytotic of fire blight (Erwinia amylovora) caused extensive losses in most orchards, particularly on the Stayman Winesap, Grimes Golden, and Jonathan varieties. Blossom blight symptoms began to appear 10 to 12 days after full bloom, and shoot blight continued for about six weeks. In some orchards 85 to 95 percent of the flowering fruit spurs of the above named varieties was affected

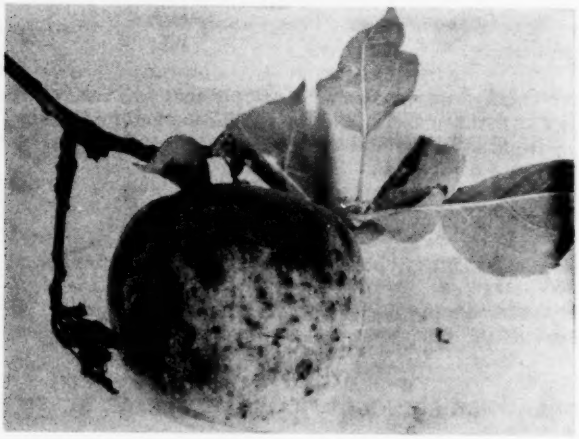

FIGURE 1. A severely infected Stayman Winesap with blighted blossoms and fruit spur with pycnidia bearing black rot inoculum.

Pycnidia bearing mature conidia of Physalospora obtusa (Schw.) Cke. were observed in the bark of twigs destroyed by fire blight by August, with black rot symptoms on the fruit appearing three to four weeks later. At first the fruits near or immediately below the blighted twigs were affected, as in Figure 1, with most of the fruit on Stayman Winesap, Grimes Golden, and Golden Delicious trees showing black rot symptoms before harvest. On these varieties the fungus entered the fruit through wounds or lenticels, but on most other varieties the entry was chiefly through wounds. In cases with severe fire blight the source of black rot inoculum was so great that the usual spray schedule was ineffective.

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OBSERVATIONS ON FOOT ROT OF ORANGE IN CALIFORNIA

F. F. Halma and K. W. Opitz

In 1932 Navel and Valencia orange trees, propagated by cuttings, were planted in various locations for comparison with budded trees on sweet orange rootstock. This report concerns one of the 18 field plots established in which an interesting foot rot (Phytophthora citrophthora) situation developed.

FIGURE 1. Navel orange cutting partly girdled by foot rot inarched with rough lemon seedlings. The healthy part was covered with chalk for contrast with the dark killed area.

The plot, located in the Leo M. Weisenberger orchard, Porterville, Tulare County, consists of two rows, one planted to 10 Navel cuttings and 9 budlings, and the other to 11 Valencia cuttings and 12 budlings. The latter also contains 2 Navel cuttings and 2 budlings. In both rows the cuttings alternate with the budlings. In 1946, when the plot was 14 years old, two Navel cuttings developed foot rot on the trunks close to and below the ground surface. A year later two more Navel cuttings were affected, and finally, in 1950, all but one of the 12 Navel cuttings showed the disease in varying degrees. Four trees died and the rest were probably saved by removing the soil in contact with the trunks and by surgery and painting with Bordeaux paste. Also, three rough lemon seedlings were inarched into each Navel cutting trunk in case the trunk should become completely girdled by the disease.

The point of interest is the fact that none of the alternately planted Navel budlings on sweet orange stock, as well as none of the Valencia cuttings or budlings, have so far shown the disease.

The trees are progenies of two Navel and two Valencia parent trees. The sweet orange rootstock is of mixed origin and undoubtedly includes many types of the species.

No sweet orange varieties are known to be immune to foot rot, as reported by Klotz and Fawcett[1] The behavior of the Navel cuttings suggests, therefore, that the bark of this variety is more easily penetrated by the fungus than is that of Valencia or the many types of sweet oranges serving as rootstock in this plot.

Corroborating evidence is reported by Robert Jennings of the East Highlands Orange Company, East Highlands, San Bernardino County. For the past several years the company has rooted and planted many Navel and Valencia cuttings. Jennings observed that a considerable number of Navel cuttings in the nursery and in the orchard have shown foot rot, particularly where the soil was heaped around the base of the tree as a protection against low temperatures. Under similar nursery and orchard conditions the loss of Valencia cuttings due to foot rot has been negligible.

Cooperation by Leo M. Weisenberger and some observations by H. C. Meith, Farm Advisor, are gratefully acknowledged.

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[1] Klotz, L. J., and H. S. Fawcett. 1930. The Relative Resistance of varieties and species of Citrus to Pythiacystis Gummosis and other Bark Diseases. Jour. Agr. Res. 41: 415-425.

DUSTING TESTS FOR CONTROL OF FUNGUS DAMAGE TO SEED COTTON IN NORTH CAROLINA IN 1951

S. G. Lehman

A number of microorganisms aided by insect and mechanical injuries are able to enter the unopened cotton boll and cause more or less damage to the cortical tissues and boll contents. When this occurs the resultant condition is commonly called boll rot. When healthy bolls crack at the tips in the early stages of boll opening, these microorganisms frequently enter through the cracks. If this occurs during a prolonged period of rainy weather, the microorganisms grow in the moist contents of the invaded locks. The lint and seed become discolored and bound together so that the lint cannot fluff out properly when the boll finally opens. This condition has been referred to as "tight lock" by Marsh and co-workers. Such cotton is usually left in the field at picking time and constitutes a very considerable loss.

Except for an occasional year when exceptionally dry weather prevails during the period of boll opening, considerable amounts of boll rot and tight lock are seen every year in North Carolina. In some years a very high percentage of the bolls produced in some areas exhibit the tight lock condition. This occurred in 1949 and 1950 in North Carolina and gave rise to requests that the possibilities of some preventive treatment be explored. Accordingly, dusting tests directed to possible control of the tight lock condition were carried through in two localities in North Carolina in 1951.

On the Everett farm near Scotland Neck, Halifax County, three dust preparations, each containing toxaphene insecticide, CP-5 dust sticker, and pyrophyllite carrier, were used. In addition to these common ingredients, one dust contained tribasic copper sulfate, another Dithane Z-78. The third dust, used as a check, contained no fungicide. Beginning on July 20, when the advanced bolls were three-quarters grown, and continuing at weekly intervals, seven applications were made by power duster. Also, in a nearby area, dusts containing the same fungicides but no insecticide were applied on smaller plots by use of hand dusters.

The percentage of unopened diseased bolls was negligible at any time during the test. At the end of the season, results were taken by examination of 100 open bolls on each plot. A record was made of each boll, indicating whether it showed no damage, had been damaged by insects only, fungi only, or both insects and fungi. Also each boll was assessed to indicate whether 1, 2, 3, or 4 locks were damaged. Little rain and no prolonged periods of wet weather favorable to tight lock development occurred during the period of boll opening. Insects had been well controlled by the grower before the initiation of this test.

In respect to damage by fungi alone or by both insects and fungi, no significant differences were found between treatments with insecticide only and treatments with both insecticide and fungicide. Nor was there any significant difference between plots which received neither insecticide nor fungicide and those which received only fungicide. The mean percentage of bolls damaged was 8.3 on plots which had received no fungicide, 12.0 for the plots dusted with copper, and 7.3 for the Dithane plots. The mean damage index, which includes a factor assessing the extent of damage to each boll, was 5.0 for the plots which had received no fungicide, 7.7 for the copper treatment, and 5.3 for the Dithane treatment. On this scale, greatest possible damage was represented by 100.

A second test was conducted on the Upper Coastal Plain Branch Station Farm near Rocky Mount. At this location tribasic copper sulfate, Dithane Z-78 (zineb), and Orthocide 406 (50% trichloromethylthio tetrahydrophthalimide) each in combination with toxaphene insecticide, were applied with rotary hand dusters. The check plots received toxaphene only.

Six applications of these dusts were made, beginning on August 3 when the most advanced bolls were nearly full grown and continuing at weekly intervals to September 7 when many bolls were open. Boll weevil damage was high on top squares at the beginning of the test and subsequent dusting gave poor control of boll weevil and little or no control of boll worm.

At the conclusion of the test, the mean percentage of open bolls having locks damaged by fungi only ranged from 3.1 for the Orthocide treatment to 5.6 for the Dithane treatment, the check plot which received no fungicide having 3.4 percent damaged bolls. A much higher percentage of the bolls showed some degree of fungus damage associated with insect injury caused largely by boll worm activity. These percentages ranged from 39 on the Orthocide plots to 42 on the control plots which received only toxaphene. Neither of the three fungicides reduced fungus damage significantly on the bolls which had also been damaged by insects.

Less than 1 percent of the open bolls examined for any treatment showed insect damage unaccompanied by fungus damage. Only a relatively small percentage of the opened bolls ap-

peared to have been damaged by fungi that entered through cracked sutures at the tip of the boll. However, a large percentage of the diseased bolls appeared to have been damaged by fungi which entered through insect injury at or near the base of the boll. In a very considerable proportion of the bolls exhibiting damage by both boll worm and fungi, the insect had not actually entered the boll but merely chewed the outer surface at the base of the boll and had thus provided a place of ingress for the fungi which subsequently damaged the seed and fiber. This circumstance indicates the great importance of insects in development of fungus damage to seed and fibers of cotton bolls. The fungicides used in these tests gave no reduction of fungus invasion through insect injuries. Reduction of this type of damage would seem to depend on elimination of the antecedent insect injury.

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DISEASES OF FORAGE CROPS IN NEW YORK, 1952

Daniel A. Roberts, Robert T. Sherwood, and Karl D. Fezer

Because no survey of forage crops diseases in New York had been made since 1928 (5), it seemed advisable to conduct such a survey in order to provide a basis for future research.

METHODS: It was determined that 25 counties, widely distributed throughout the State, maintain more than two-thirds of the dairy cattle and produce approximately two-thirds of the forage legumes and grasses in New York (8). Survey itineraries were planned so as to include visits to each of these counties prior to the first and the second cuttings of hay. The number of fields selected for inspection in each county was roughly proportional to total forage crop production there. Routes of travel were so selected that fields representative of entire counties could be visited. Fields for inspection were selected at random, provided that no two fields of the same crops occurred less than 5 highway miles apart. A modification of the method reported by Houseman et al. (6) was used to select areas within each field for study. Three surveyors entered each field at points approximately 100 yards apart, and advanced into the field for some 25 yards. Each surveyor examined closely the plants occurring within a radius of at least 5 yards about the point reached, and then examined plants in two other areas of at least 10 square feet each before leaving the field.

The percentage of infected plants was determined in the case of each disease observed, and the severity of each disease was rated numerically. The approximate percentage of crop loss corresponding to the severity ratings had been determined in diseased samples by measurement of portions of plants rendered worthless by disease. It was calculated that percentage losses of approximately 2.5, 20, 50, and 80 corresponded to severity ratings 1, 2, 3, and 4, respectively. A rating of 5 indicated death of the plants involved. An estimate of State-wide crop losses caused by each disease was obtained by multiplying the percentage of diseased plants by the percentage loss corresponding to the average disease severity rating. For diseases not characterized by foliage or stem lesions, the amount of crop loss was estimated on the basis of the percentages of diseased and killed plants.

RESULTS: The role played by diseases in losses of legume stands is difficult to determine. From the data obtained, it is not possible to make an accurate appraisal of losses caused by root rots and wilt diseases of legumes in New York meadows and pastures, but it has been shown that bacterial and Fusarium wilts, root rots caused by Fusarium spp. and Rhizoctonia sp., and crown rot caused by Sclerotinia trifoliorum Eriks. are partly responsible for losses in many stands (5, 7). These diseases occurred in New York during 1952, and it is estimated that they caused a 2 to 5 percent loss of meadow crops.

Losses caused by the most serious foliage and stem diseases are presented in Table 1. Other diseases observed, but which caused a total loss amounting to less than 1 percent of the affected crop in 1952, were: anthracnose, yellow leaf blotch, Pseudoplea leafspot, and mosaic of alfalfa; powdery mildew, Pseudoplea leafspot, and Cercospora leafspot of red clover; Stagonospora leafspot and leaf rust of white and ladino clovers; leaf scald, stripe smut, and leaf rust of timothy; and leaf rust of orchard grass. It is likely that losses due to leaf rusts and smuts of grasses and to powdery mildew of red clover would have been considered more serious had a survey been conducted in the late summer or early autumn.

DISCUSSION AND SUMMARY: Despite the errors inherent in plant disease surveys (1, 5), the results of the one reported here certainly indicate the relative importance of commonly-occurring forage crops diseases in New York during 1952.

The most serious diseases observed were: root rots, common leafspot, spring blackstem, Stagonospora leafspot, and bacterial wilt of alfalfa; sooty blotch, Pseudopeziza leafspot, Stemphylium leafspot, Northern anthracnose, leaf rust, root rots, and mosaic virus diseases of red clover; Cercospora leafspot, Pleospora leafspot, root and stolon rots, and mosaic virus diseases of white and ladino clovers; Stemphylium leafspot and stem canker of birdsfoot trefoil; Heterosporium leafspot and leaf streak of timothy; leaf streak and purple leafspot of orchard grass; and Helminthosporium leaf blight of brome grass.

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Table 1. Estimated crop losses caused by some foliage and stem diseases of forage legumes and grasses in New York,

Table 1. Estimated crop losses caused by some foliage and stem diseases of forage legumes and grasses in New York, 1952.

Crop	Disease[a]	First cutting			Second cutting		
		Number fields inspected	Fields showing disease	Loss	Number fields inspected	Fields showing disease	Loss
			%	%		%	%
Alfalfa	Common leafspot	37	79	2.3	23	87	1.5
	Spring blackstem		80	2.0		57	0.5
	Stagonospora leafspot		60	1.2		87	1.6[b]
	Downy mildew		33	0.3		4	---
Red clover	Sooty blotch	37	54	2.3	26	54	0.1
	Pseudopeziza leafspot (5)		43	1.1		65	0.4
	Stemphylium leafspot		68	0.8		65	1.4
	Northern anthracnose		45	0.5		46	0.3
	Leaf rust		43	0.3[b]		73	1.3[b]
	Mosaic virus diseases		60	---		88	---
White and ladino clovers	Cercospora leafspot (5)	11	72	1.0	8	32	0.4
	Pseudoplea leafspot		18	0.2[b]		75	0.5[b]
	Mosaic virus diseases		79	---		32	---
Birdsfoot trefoil	Stemphylium leafspot (3)	1	100	1.0	10	100	1.3
Timothy	Heterosporium leafspot (5)	44	89	2.6	29	100	1.7
	Leaf streak		78	0.5		73	0.5
Orchard grass	Leaf streak	10	100	2.0	9	45	0.6
	Purple leafspot (4)		80	2.0		45	0.4
	Leaf scald		80	1.1		22	0.3
Brome grass	Helminthosporium leaf blight	3	100	1.7	5	100	2.5

[a] Common names as presented by Dickson (2) except where names are followed by numbers in parentheses which refer to Literature Cited.
[b] Loss not determined.

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THE EFFECT OF TEMPERATURE ON THE RESULTS OF SEED TREATMENT OF SMALL-SEEDED LEGUMES

J. W. Gerdemann

In popular reports the statement is often made that the greatest benefit from seed treatment of small-seeded legumes will be obtained when treated seed is planted in cold wet soil. This implies that preemergence damping-off is most severe under these conditions. Leach[1] reported that the degree of preemergence damping-off depended on the relative growth rates of host and pathogen at different temperatures. A high temperature crop such as watermelon escaped injury at high temperatures but was increasingly injured as the temperature was lowered. A low temperature crop such as spinach escaped preemergence damping-off at low temperatures but was severely injured at high temperatures. Since most small-seeded legumes can be considered low temperature crops, preemergence damping-off might be expected to be most severe in warm wet soil.

The following experiment was conducted to determine the effect of temperature on preemergence damping-off of red clover. Untreated seed and seed treated with 0.5 percent Arasan were used in this experiment. One hundred seeds from each treatment were planted in greenhouse flats in warm and in cold soil. Each treatment was replicated six times at both temperatures. In order to assure a high degree of damping-off the soil had been previously steam sterilized and infested with a pathogenic Pythium isolate. The soil temperature of the warm series ranged from 70° to 75° and that of the cold series ranged from 45° to 55° F. The soil at both temperatures was kept continuously wet.

Mean emergence from treated and untreated red clover seed in warm and cold soil

Treatment	Warm soil	Cold soil
	percent	percent
Check	14.3	59.7
.5% Arasan	24.5	59.5

	F values		
		Required	
Source of variation	Obtained	5% level	1% level
Temperature	246.7	5.12	10.56
Treatment	4.4	5.12	10.56
Treatment x temperature	4.67	5.12	10.56

The F value for the effect of temperature greatly exceeded that required for significance at the 1 percent level, indicating that red clover was more susceptible to preemergence damping-off in warm soil than in cold soil. The F values for treatment and treatment x temperature interaction were not significant at the 5 percent level; however, there is an indication that Arasan partially controlled preemergence damping-off in the warm soil.

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[1]Leach, L.D. 1947. Growth rates of host and pathogen as factors determining the severity of preemergence damping-off. Jour. Agr. Res. 75: 161-179.

SMALL GRAIN DISEASES OF THE SOUTHEASTERN COASTAL PLAIN, 1951-52

R. W. Earhart

Small grain diseases were widespread in the Southeastern Coastal Plain during the 1951-52 growing season, but they caused serious damage only in certain isolated instances. The limited damage probably resulted from the increased use of more resistant varieties with wider adaptation, since the season, as a whole, was favorable for the development of the major diseases. The maximum and minimum temperature and rainfall for each month of the growing season of 1951-52 at four principal Stations[1] of this region are presented in Table 1.

Table 1. Monthly absolute maximum and minimum temperatures, and rainfall at four Stations in the Southeastern Coastal Plain from October 1, 1951 to May 15, 1952.

	Station	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	
a. Temperature, °F.										Mean
Max.	Gainesville	94	88	87	82	83	85	91	88	87
	Quincy	94	87	81	80	79	81	84	84	84
	Jay	92	90	81	83	81	82	86	85	85
	Tifton	94	86	80	79	80	79	83	94	84
Min.	Gainesville	51	31	28	30	29	34	40	40	35
	Quincy	43	28	26	28	26	32	36	38	32
	Jay	42	24	24	27	27	35	34	41	32
	Tifton	42	27	18	23	25	33	31	40	30
b. Rainfall (inches)										Total
	Gainesville	3.0	6.8	1.7	0.8	6.0	3.0	3.2	1.4	25.9
	Quincy	1.0	6.3	7.6	0.9	5.3	5.0	5.8	0.8	32.7
	Jay	0.7	3.5	4.6	1.7	5.2	5.8	7.6	0.0	29.2
	Tifton	0.3	3.7	6.8	0.5	4.1	3.9	4.8	2.1	26.2

Oat Diseases

1. Oat crown rust, Puccinia coronata avenae, was again the most damaging disease attacking any of these crops. It was observed at Gainesville on December 4 but build-ups were not noted in farmers' fields until the middle of February. However, the larger acreage of Southland (C.I. 5207), which has considerable field resistance to races 45 and 57, greatly reduced the amount of damage sustained by the oat crop. More rust was found on this variety than had previously been reported owing to the greater prevalence of races 55 and 101, to which Southland is susceptible. To combat the spread of these newer races, the Florida Agricultural Experiment Stations are releasing a new oat possessing "Landhafer resistance" to races 55 and 101, for planting in 1952. This oat, selected from the cross Florida 167 x Landhafer, has been named Floriland (C.I. 6588).

2. Oat stem rust, Puccinia graminis avenae, while generally not considered serious in this area, caused considerable damage for the second time in three seasons. The outbreaks probably are due to a shift in prevailing races. Races 2, 5, 7, and 8 were recorded from Florida this season. Race 7 was reported from the region for the first time in 1950. No varieties in commercial production at present possess resistance to races 7 and 8, but breeding work is directed towards incorporating resistance to these races into agronomically adapted lines. Stem rust was observed at Gainesville on March 21 and was found in all oat growing areas of the region by the end of the season. Little damage was sustained by the crop as a whole since most of the fields were attacked late in the season.

[1]These are located at: Gainesville, Quincy, and Jay, Florida, and Tifton, Georgia.

3. Oat culm rot, Helminthosporium sativum, a disease recently reported in this area, occurred in all areas of the region throughout the season. Severity ranged from light to complete killing depending upon the management and previous cropping of the field. Complete killing occurred only with the combination of "no rotation" and "too close grazing". This disease, like many others, seriously attacks plants that have been weakened by low nutrition, overgrazing, cold, or probably drought. Symptoms vary according to the stage of host development. Seedlings show a basal rot, generally at the crown or sub-crown internode, and more mature plants show a reddening and stunting, with little if any necrosis. In closely grazed pastures, the plants die quickly and uniformly. Culm rotting symptoms occur on infected plants at the time the panicles are filling, when the lower culms of healthy looking plants become water-soaked and darkened with culm breakage occurring at the first or second node. Frequently, the area of breakage is covered with black conidiophores and conidia of the fungus.

Laboratory tests indicate a wide range in varietal susceptibility to culm rot. Breeding to secure culm rot resistance in adapted oat lines has been started at the Florida Agricultural Experiment Stations. However, much can be done towards controlling this disease by sowing cleaned, treated seed on land that has not been cropped to oats for at least two years and then following recommended fertilizer and pasture management practices. The rotation of oat land is essential because the fungus causing this disease can live in the soil as a saprophyte from one growing season to the next. However, it also is carried on the seed.

4. Oat leaf spot, Helminthosporium avenae, is widespread in this area. It can be found in every oat field from the time of emergence until harvest. Every lot of Florida grown oat seed, so far tested, has carried this fungus in high amounts. The disease is very sensitive to climatic conditions, requiring high relative humidities for maximum spread. This season the leaf spotting phase was present in sufficient amounts to cause some damage in nearly all areas, especially in the more southern portions of the region. The fungus, like that causing culm rot, is capable of growing saprophytically in the soil from one cropping season to the next. Therefore, adequate rotation must be practiced to prevent re-infection from the soil. The change in oat varieties is bringing about an increase in leaf spot severity. The Landhafer lines are considerably more susceptible to this disease than were the older varieties, especially the Red Rustproof types.

5. Other oat diseases recorded during 1951-52.

a. Oat smuts, Ustilago kolleri and U. avenae.
b. Victoria blight, Helminthosporium victoriae.
c. Powdery mildew, Erysiphe graminis avenae.
d. Halo blight, Pseudomonas coronafaciens.
e. Bacterial stripe, Pseudomonas striafaciens.
f. Downy mildew, Sclerospora macrospora.
g. Septoria black stem, Septoria avenaria.
h. Red leaf, unknown causes.

Wheat Diseases

1. Wheat leaf rust, Puccinia rubigo-vera tritici, was by far the most serious disease attacking wheat during the past season. An infection center was found at Gainesville on December 12, and before the end of the season this disease had been located in damaging amounts in all areas. Six distinct races of the fungus have been identified. In order of prevalence the races are: 5, 15, 126, 9, 11, and 58. Susceptible wheat varieties were damaged seriously in localized areas by this disease, to the extent that reductions in yield and bushel weights were recorded.

2. Wheat stem rust, Puccinia graminis tritici, appeared earlier and was more prevalent than at any time in the past three seasons. Infection centers were reported from Quincy on April 17, and from Live Oak, Florida, on April 18. Shortly thereafter, stem rust was found in every field of wheat examined over this entire area. Four races of the fungus have been identified, viz., 15, 15B, 17, and 56. This is the first report of race 15B from this part of the country. While the disease was widespread, serious damage occurred only in isolated localities. The spread from the original centers of infection was too slow to cause severe damage to the crop, although infection was general throughout most fields by the end of the season. The spread in the fields may have been retarded by low temperatures in April.

3. Wheat powdery mildew, Erysiphe graminis tritici, was serious only in local areas, mostly in the more northern portions of this region. Severe outbreaks occurred at Quincy and Tifton. At Tifton it was undoubtedly a factor in the low wheat yields recorded there. This dis-

ease was noted at Tifton on January 16, and was present for the rest of the season. Ordinarily powdery mildew diminishes in intensity as warmer weather and more sunshiny days occur late in the season, but this did not happen at Tifton. The infections at Quincy, and other locations, did not reduce yields or test weights.

4. Other wheat diseases recorded 1951-52.

a. Wheat loose smut, Ustilago tritici.
b. Septoria leaf blotch, Septoria tritici.

Rye Diseases

1. Rye leaf rust, Puccinia rubigo-vera secalis, was the only damaging disease attacking rye. Infections were noted in the Tifton area on January 12, and by early February it was prevalent in all north Florida and south Georgia areas.

2. Rye stem rusts, Puccinia graminis vars. secalis and tritici, were widespread, but infection was late, and little if any damage was sustained by the crop. Infection was noted at Gainesville on April 8, which is only about two weeks before the crop normally matures in the area. Races 15B and 17 of Puccinia graminis tritici were collected on rye at Marianna, Florida.

3. Other diseases recorded on rye, 1951-52.

a. Helminthosporium leaf blotch, Helminthosporium tritici-repentis.

U. S. BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING, DIVISION OF CEREAL CROPS AND DISEASES, AND THE FLORIDA AGRICULTURAL EXPERIMENT STATION, GAINESVILLE, FLORIDA

RESULTS FROM TESTS FOR THE CONTROL OF DWARF BUNT BY APPLYING FUNGICIDES TO INFESTED SOIL

C. S. Holton and T. L. Jackson

Exploratory tests were conducted in 1952 on the possible control of dwarf bunt due to soil-infestation in the Pacific Northwest by the application of fungicides to the soil at the time of seeding winter wheat. The fungicides included in the test were: Ceresan M, Spergon, Agrox, and Anticarie. They were applied with a conventional-type duster, powered by a gasoline motor, and mounted on a four-row custom-built seeder. Each of the four dust-delivering tubes was attached to a drill spout, so that the fungicide was blown into the drill-opening simultaneously with seed delivery. Each treatment was in blocks of four rows, 100 feet long, spaced one foot apart, and replicated three times, making a total of 1200 lineal feet of rows.

The fungicides were reduced to half strength by mixing them with equal amounts of either pumicite or talc. The diluted dusts were applied to the soil at the rate of about 200 pounds per acre in each of five locations in the Pacific Northwest. Smut percentages were determined by examining 100 heads at each of 12 random locations in each plot. The results are presented in Table 1.

Table 1. Results of soil-treatment tests with four fungicides for the control of dwarf bunt in four varieties of winter wheat in the Pacific Northwest.

Soil treatment	Percent of dwarf bunt in varieties, indicated, at --				
	Troy, Idaho	Worley, Idaho	Elgin, Oregon	Waterville, Washington	Goldendale, Washington
	Golden	Elgin	Elgin	Rio	Orin
Check	32	48	41	11	Tr.
Ceresan M*	34	31	37	2	Tr.
Spergon	46	54	48	9	Tr.
Agrox*	22	15	56	3	Tr.
Anticarie	2	0	33	0.7	Tr.

*These materials reduced the stand materially in all plots.

Of the four fungicides tested, only Anticarie gave significant control of dwarf bunt. It was highly effective in three locations but only slightly effective at a fourth location (Elgin, Oregon). The amount of smut at the fifth location (Goldendale, Washington) was too low for evaluation of the fungicides.

Ceresan M and Agrox reduced the stand materially below that of the check rows. There was no reduction of stand in the plots treated with Spergon or Anticarie. At three locations the Spergon plots had more smut than the untreated plots. Further tests with Anticarie and other chlorobenzene compounds are in progress at rates of application that are more nearly practical economically.

Soil infestation by dwarf bunt has become a problem of increasing importance in the winter-wheat areas of the Pacific Northwest. Unlike the common form of bunt, dwarf bunt can persist in the soil for more than one year, even in the absence of a wheat crop. Seed treatment is ineffective in preventing infection due to this soil-borne inoculum. Therefore, it is hoped that a practical method of control by soil disinfection at seeding time can be developed.

U. S. BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING, DIVISION OF CEREAL CROPS AND DISEASES, IN COOPERATION WITH WASHINGTON AGRICULTURAL EXPERIMENT STATIONS

SEED-TREATMENT TESTS FOR BUNT CONTROL IN WINTER AND SPRING WHEATS IN 1952

C. S. Holton and John Y. Woo

Two seed-treatments tests for bunt control with chemical fungicides were made at Pullman, Washington, in 1952. One of these tests was on Triumph winter wheat, seeded in October 1951, and the other was on Red Bobs spring wheat, seeded in April, 1952. In July, 1952, the percentages of smut were obtained by counting the smutted heads and the total heads in each row. In rows with no smut, head counts were not made. All rows had full and approximately equal stands of plants. The results are presented in Table 1 for winter wheat and spring wheat, respectively.

The fungicides were applied at the indicated rates (Table 1) as dusts, slurries, or liquids. Samples of 125 grams of Triumph wheat and 250 cc. of Red Bobs wheat were used for each treatment. After applying the fungicides, the seed was thoroughly agitated in closed glass containers until coverage of the seed by the fungicide was assured. It was then left covered for 24 hours. A sticking agent (Methocel) was used in some samples to determine its effectiveness in holding the dust on the seed. Each lot of treated seed was planted in replications of three rows.

In both tests, most of the materials were highly effective in controlling bunt, in comparison with the standard commercial treatment, Ceresan M. Among the effective new treatments are the mercury compounds Agrox, Panogen, Mergamma, Setrete, M.E.M.A., Mercusol, and Merculine. The non-mercurials included copper carbonate, Orthocide, Actidione, hexachlorobenzene (Anticarie), and pentachlornitrobenzene (Plant Fungi Control, Tritisan, and Brassicol). Copper carbonate (50%), used as a slurry, was difficult to apply but nevertheless effective. The sticking agent, Methocel, was not effective in holding the dust on the seed after the water had evaporated from the slurry-treated seed.

Poor control was given by Orthocide 406, Actidione, and Plant Fungi Control. This last compound, which is 20 percent pentachlornitrobenzene, gave good control in previous years, thus indicating that the supply used this year had deteriorated with age.

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Table 1. Relative effectiveness of fungicidal materials in the control of bunt in Triumph winter wheat and Red Bobs spring wheat, grown from bunt-inoculated seed, treated as shown, and planted in triplicated rod-rows at Pullman, Washington, 1951-52.

Triumph winter wheat						Red Bobs spring wheat					
Seed treatment					Percent bunt	Seed treatment					Percent bunt
No.	Material	Form	Oz/bu	Sticker used?		No.	Material	Form	Oz/bu	Percent sticker	
1.	Untreated check	----	----	----	49	1.	Untreated check	----	----	----	67
2.	Ceresan M	Slurry	1/2	No	0	2.	Agrox	Dust	1/2	0	0.1
3.	Ceresan M	Slurry	1/2	Yes	0	3.	Agrox	Slurry	1/2	0	0.6
4.	Agrox	Slurry	1/2	No	0	4.	Mycon	Slurry	1/2	0	0
5.	Agrox	Slurry	1/2	Yes	0.3	5.	Agrox	Slurry	1/2	0.25	0
6.	Anticarie	Slurry	1/2	No	0	6.	Agrox	Slurry	1/2	0.75	0
7.	Anticarie	Dust	1/2	No	0	7.	Agrox	Slurry	1/2	1.00	0
8.	Copper carbonate	Slurry	3	No	1	8.	Agrox	Slurry	1/2	1.50	0
9.	Copper carbonate	Slurry	3	Yes	0	9.	Setrete	Liquid	1/2	0	0
10.	Untreated check	----	----	----	50	10.	Untreated check	----	----	----	66
11.	Panogen 1.4 % Hg	Liquid	3/4	No	0.3	11.	Mergamma	Dust	1 3/4	0	0
12.	Panogen 1.7 % Hg	Liquid	3/4	No	0	12.	Mergamma	Slurry	1 3/4	0	0
13.	Panogen 2.0 % Hg	Liquid	3/4	No	0	13.	Tritisan	Dust	2	0	0
14.	Plant Fungi Control	Slurry	1/2	No	9	14.	Brassicol	Dust	2	0	0
15.	Plant Fungi Control	Slurry	1/2	Yes	21	15.	Ceresan M	Dust	1/2	0	1.2
16.	Hexachlorobenzene 60 %	Dust	1/2	No	0	16.	Ceresan M	Slurry	1/2	0	0
17.	Hexachlorobenzene 24 %	Dust	1/2	No	0	17.	Mercusol	Liquid	1/2	0	1.4
18.	B.H.C. 50% + H.C.B. 25%	Dust	1	No	0	18.	Merculine	Liquid	1/2	0	0
19.	Phygon pellets	Slurry	1/2	No	4.6	19.	M.E.M.A.	Liquid	1/2	0	0.1
20.	Panogen 1.5 % Hg	Liquid	3/4	No	0	20.	Panogen	Liquid	3/4	0	0
21.	Mergamma	Slurry	2	No	0	21.	Anticarie	Dust	1/2	0	0
22.	Mergamma	Slurry	2	Yes	0	22.	Anticarie	Slurry	1/2	0	0
23.	M.E.M.A.	Liquid	1/2	No	0						
24.	Orthocide 406	Slurry	1/2	No	40						
25.	Actidione (10 p.p.m.)	Dust	----	No	30						
26.	Untreated check	----	----	----	43						

SEED TREATMENT TESTS ON SORGHUM IN 1952

R. W. Leukel and O. J. Webster

In 1952 twelve fungicides were applied to smut-infested seed of Sharon kafir. Six of these were applied as dusts only; three both as dusts and slurries; and three as liquid treatments.

The materials not previously tested on sorghum were Mycon, Orthocide 406, M.E.M.A., and two experimental products, 5202-K and 5025-S.

The experimental procedure was similar to that described for previous tests of seed treatments for sorghum (1, 2, 3, 4). The chemicals were applied to 500 cc samples in containers of 1000 cc capacity with dust-tight covers. Emergence tests of treated and untreated seed were made in triplicate in steamed soil and in soil infested with pathogenic soil fungi. The temperature was kept at 15° to 20° C for seven days after planting and then at 26° to 28° until after emergence. Field plantings were made at Beltsville, Maryland and Lincoln, Nebraska in 33-foot rows replicated three times for each treatment. One hundred and fifty seeds were planted per row and the rows were randomized.

Experimental Results

None of the treatments caused any reduction in emergence in steamed soil and all of them improved emergence in infested soil (Table 1). These increases in emergence ranged from 23 to 41 percent.

Seedling stand counts were made in the field, at both stations, but they yielded no data of value. Soil washing, differences in depth of planting, in drainage, and in soil moisture, along with other factors caused variations in stand that masked any differences that could have been due to the treatments.

The total number of heads and the number of smutted heads, in each row, were counted and the average percent of infection calculated (Table 1).

Eleven treatments (eight fungicides) eliminated covered smut at both stations, with an average infection of 57 percent and 36 percent from untreated seed at Beltsville and Lincoln respectively. M.E.M.A. allowed one smutted head, copper carbonate four heads, and C & C 640 and L-224 eight heads each.

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U. S. BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING, DIVISION OF CEREAL CROPS AND DISEASES IN COOPERATION WITH THE NEBRASKA EXPERIMENT STATION

Table 1. Effect of seed treatment with different fungicides on the percentage of emergence in Sharon kafir in steamed and in infested soil, and on the control of covered kernel smut in field plots in 1952.

Treatment No.	Material	Oz/bu	Form	Percent emergence in soil: Steamed	Percent emergence in soil: Infested	Total and smutted heads at Beltsville: Total no.	Beltsville: Smutted No.	Beltsville: Smutted Percent	Lincoln: Total no.	Lincoln: Smutted No.	Lincoln: Smutted Percent	Average percent smut
1.	Check	---	---	90	62	157	95	60.5	143	47	32.9	47.3
2.	Arasan	2	Dust	94	89	230	0	0	---	---	---	0
3.	Phygon	2	Dust	92	86	202	0	0	---	---	---	0
4.	Mycon	2	Dust	92	89	205	0	0	188	0	0	0
5.	Orthocide	2	Dust	96	82	186	0	0	221	0	0	0
6.	$CuCO_3$	2	Dust	93	89	200	1	0.5	243	3	1.2	0.9
7.	5202 K	2	Dust	97	89	205	0	0	182	0	0	0
8.	C & C No. 640	2	Dust	90	86	234	4	1.7	202	0	0	0.9
9.	C & C No. L-224	0.5	Dust	92	89	190	1	0.5	179	7	3.9	2.2
10.	Ceresan M	0.5	Dust	95	90	180	0	0	163	0	0	0
11.	Check	---	---	93	70	170	91	53.5	148	58	39.2	46.9
12.	Arasan S.F.K.	2	Slurry	92	82	206	0	0	198	0	0	0
13.	Phygon	2	Slurry	95	82	223	0	0	209	0	0	0
14.	5202 K	2	Slurry	90	93	223	0	0	228	0	0	0
15.	MEMA	0.5	Wet	98	90	188	0	0	178	1	0.6	0.3
16.	Vancide 51	4	Wet	92	90	186	0	0	173	0	0	0
17.	5025-S	2	Wet	93	81	187	0	0	172	0	0	0

COOPERATIVE TESTS WITH FUNGICIDES FOR SMUT CONTROL IN WHEAT AND OATS IN 1952

R. W. Leukel

In 1952 fourteen materials were tested for the control of bunt in Ulka spring wheat and eleven for the control of smuts in Canadian oats.

As in the previous cooperative tests of this nature, the seed was treated and packeted at the Plant Industry Station, Beltsville, Maryland, and sent to the different field stations, where it was planted by the respective cooperators, who later also recorded the data on infection. The writer is indebted to the following for their cooperation:

D. C. Arny, Madison, Wisconsin; W. E. Brentzel, Fargo, North Dakota; R. M. Caldwell, LaFayette, Indiana; D. M. Coe, Palmer, Alaska; C. S. Holton, Pullman, Washington; B. Koehler, Urbana, Illinois; C. W. Roane, Blacksburg, Virginia; and J. R. Vaughan, East Lansing, Michigan.

The sources of materials, the method of inoculating and treating seed and testing its germination, and the other details of procedure have been discussed previously (3, 4, 5). Several materials were used that were not included in previous tests. They are:

Setrete -- 7% phenyl mercuric ammonium acetate (4% Hg), produced by W. A. Cleary Corporation, New Brunswick, New Jersey. This material is in liquid form and may be applied as a quick wet treatment, or in a slurry treater when properly diluted with water.

MEMA -- 4% mercury in an organic mercuric compound, produced by the Chipman Chemical Company. It was applied at 1/2 ounce per bushel in an aqueous solution that added less than 1 percent of water to the seed.

Tag 331 -- 10% phenyl mercuric acetate (5.9% Hg) produced by California Spray-Chemical Company, Haddonfield, New Jersey, is similar to Setrete in form and composition, but at present (October 1952) is not commercially available. It can be applied in a slurry treater, when properly diluted with water.

Mycon -- 7.7% methyl arsenic sulfide (4.7% arsenic) is made by Pittsburgh Agricultural Chemical Company, Empire State Building, New York. It was used as a dust but may be applied also as a slurry. It is not yet commercially available but may be on the market in 1953.

Germination tests of the treated and untreated lots of Ulka wheat were made in triplicate in steamed uninoculated soil, and in nonsteamed soil, inoculated with Fusarium graminearum and F. culmorum. Cultures of these fungi had been obtained from Dr. W. L. Gordon, Fort Garry, Manitoba, Canada. The tests were made in pans 4 x 8 x 2 inches, in each of which 100 seeds were planted one inch deep. These small pans were placed on moist blotters in larger covered pans. The pans were kept at 10° C. for ten days and then at 20° C. until emergence was complete. The data on emergence are shown in Table 1.

Experimental Results

In the steamed soil none of the fungicides, with the possible exception of Mergamma, applied at 2 ounces per bushel, had any depressing effect upon emergence. With 98 percent emergence from untreated seed, benefits due to treatment could hardly be expected.

In the infested soil, emergence was improved by all treatments except Mergamma (2 ounces), N.P. 679, and Anticarie. It is not clear why the two latter materials seemed to depress emergence in infested soil, while not affecting it significantly in steamed soil.

Only eight of the 22 treatments reduced the average bunt infection to less than 0.5 percent. When a material was applied both in slurry and in dust form, the slurry form of treatment was the more effective in bunt control. As a class, the materials applied as liquid treatments were more effective in bunt control than the dusts or slurries.

In the control of oat smuts (Table 2) only Ceresan M slurry, Panogen and Mycon were 100 percent effective at all of the nine stations. All of the other treatments, however, except Dynacide and, at some stations, N.P. 679 and Vancide, gave fairly good control. The highest percentages of infection occurred at Blacksburg, where seven treatments (five materials) allowed more than 1.0 percent smut.

Perhaps the poorest control of oat smuts was obtained at Fargo, where, although the

Table 1. Percent emergence from untreated and treated, bunt-infested seed of Ulka spring wheat planted in steamed and in infested soil; and percent of smutted heads in plants grown from this seed sown at eight field stations in 1952.

Seed treatment				Percent emergence[a]		Percent heads infected in plots at								Average percent infection
No.	Fungicide	Form	Oz/bu	1	2	Urbana, Illinois	Beltsville, Maryland	Madison, Wisconsin	St. Paul, Minnesota	Fargo, North Dakota	Pullman, Washington	Palmer, Alaska		
1.	No treatment	----	----	98	81	10.0	12.8	43.1	13.5	3.1	72.0	55.5		30.0
2.	Ceresan M	Dust	1/2	95	94	0	0	1.3	0	0.3	3.0	3.5		1.2
3.	Agrox	Dust	1/2	98	94	0.2	0.1	4.0	1.4	1.8	9.0	2.1		2.7
4.	Mergamma	Dust	2	88	81	0	0.3	1.5	0	3.3	4.0	0.2		1.3
5.	Mergamma	Dust	1	92	93	1.4	2.0	14.4	0	1.4	19.0	7.4		6.5
6.	Dynacide	Dust	1/2	94	94	0.7	4.0	11.3	2.0	3.1	21.0	16.8		8.4
7.	N.P. 679	Dust	1	92	62	9.0	9.0	31.5	7.9	9.0	78.0	67.0		30.2
8.	Ceresan M	Slurry	1/2	96	93	0	0	0	0	0	0	0.2		t
9.	Agrox	Slurry	1/2	96	94	0.2	0	0.8	0	0	1.5	0.8		0.5
10.	Mergamma	Slurry	1 1/2	93	86	0.2	0.1	0.3	0	0	1.0	2.9		0.6
11.	No treatment	----	----	98	83	8.6	13.5	27.3	12.4	1.4	79.0	53.8		28.0
12.	Dynacide	Slurry	1/2	96	95	0	4.0	5.1	0.2	0.2	5.0	2.5		2.4
13.	M.E.M.A.	Liquid	1/2	95	99	0	0	0.4	0	0	0.1	0.2		0.1
14.	Setrete	Liquid	1/2	94	94	0	0	0.4	0	0	0.7	0		0.2
15.	Tag 331	Liquid	1/2	92	93	0	0	0.5	0	0	0	0.4		0.1
16.	Panogen	Liquid	3/4	98	96	0	0	0.1	0	0	0	0.1		t
17.	Vancide 51	Liquid	4	97	96	0.2	0	1.3	0.2	0	0.3	2.2		0.6
18.	275 D	Dust	2	96	85	0	0	0.3	0	0.2	0	0.1		0.1
19.	Mycon	Dust	2	96	92	0	0	0	0.2	0	0.3	0.6		0.2
20.	Orthocide	Dust	2	96	91	1.2	3.2	2.7	0	1.7	5.0	8.8		3.2
21.	Anticarie	Dust	1/2	94	74	0	0	1.3	0	0.8	0.3	0		0.3
22.	Anticarie	Slurry	1/2	95	86	---	0	---	---	0	0	---		0
23.	Experimental	Dust		94	90	---	9.5	---	---	8.2	66.0	---		27.9
24.	Experimental	Dust		95	92	---	8.0	---	---	10.0	87.0	---		35.0

[a] 1 in steamed soil
2 in infested soil

checks averaged only 4 percent infection, eight treatments with seven materials allowed over 1 percent smut. At St. Paul, where the checks averaged 11.1 percent infection, ten treatments eliminated smut completely, and all the rest except one allowed a mere trace.

These seeming inconsistencies are pointed out to emphasize the importance of testing fungicides under a variety of conditions and over a period of several years before making a final evaluation of their effectiveness. At times, certain materials that have been used as standards of comparison for several years because of their consistent efficiency seem to allow an unusually high percentage of infection in one row. The discrepancy may be due to human error or to some other unobserved cause. Untreated seed, or seed treated with an ineffective material and sown next to a row of effectively-treated seed, may inadvertently be carried into an adjacent row by wind, water, or some other agent. Seed envelopes may become misplaced and the seed sown in the wrong row in spite of the usual precautions. Such occurrences, although rare, may offer the only logical explanation for an extreme incongruity in data. Hence the desirability of duplication and repetition of seed treatment tests is emphasized.

Table 2. Control of loose and covered smuts in Canadian oats grown from naturally infected seed, treated with different fungicides, and sown in triplicated rod-rows at field stations in eight States and Alaska in 1952.

Treatment applied				Percent of heads infected in plots at									Average of all stations
No.	Fungicide	Form	Oz/bu	Urbana, Illinois	Blacksburg, Virginia	Beltsville, Maryland	Maidson, Wisconsin	East Lansing, Michigan	St. Paul, Minnesota	Fargo, North Dakota	Pullman, Washington	Palmer, Alaska	
1.	Check	----	----	7.0	26.2	15.7	16.4	14.9	11.4	2.8	10.0	3.8	12.0
2.	Ceresan M	Dust	1/2	0	0	0	0	2.6	0	0	0	0	0.3
3.	Agrox	Dust	1/2	0.3	0.7	0	0.8	0	0	0.1	0.3	0.2	0.3
4.	Mergamma	Dust	2	0.2	0.4	0	0.1	1.0	0	0.2	1.6	0	0.4
5.	Mergamma	Dust	1	0.1	1.1	1.3	1.3	2.5	0	0.4	0.8	0	0.8
6.	Dynacide	Dust	1/2	0.6	4.2	0.3	2.6	6.4	0.1	4.5	2.8	0.2	2.4
7.	N.P. 679	Dust	1	0.7	5.4	2.5	4.5	8.0	1.0	1.8	1.8	0	2.9
8.	Ceresan M	Slurry	1/2	0	0	0	0	0	0	0	0	0	0
9.	Agrox	Slurry	1/2	0.1	1.6	0.3	1.3	0	0.1	0.4	0.3	0	0.5
10.	Mergamma	Slurry	1 1/2	0.2	2.9	0.6	2.6	2.8	0.1	3.0	3.3	0	1.5
11.	Check	----	----	6.4	21.1	17.0	15.8	23.8	10.8	5.1	14.0	1.3	12.8
12.	Dynacide	Slurry	1/2	1.7	4.6	2.0	5.3	22.8	0.1	3.6	5.0	0.6	9.1
13.	M.E.M.A.	Liquid	1/2	0.8	0.2	0	1.4	1.4	0.1	3.4	0.3	0.1	0.9
14.	Setrete	Liquid	1/2	0.2	0.2	0.7	0.5	3.2	0	2.1	1.2	0.1	0.9
15.	Tag 331	Liquid	1/2	0.2	0.3	0.5	0.4	1.2	0	1.3	0.1	0.1	0.5
16.	Panogen	Liquid	3/4	0	0	0	0	0	0	0	0	0	0
17.	Vancide 51	Liquid	4	0.3	2.4	0.8	1.9	2.5	0	1.5	2.0	0.3	1.3
18.	Mycon	Dust	2	0	0	0	0	0	0	0	0	0	0
19.	Experimental	Dust	2	5.3	33.0	15.5	26.0	---	---	---	---	---	20.0
20.	Experimental	Dust	4	4.2	30.8	10.7	14.2	---	---	---	---	---	15.0

Present Trends in Cereal Seed Treatment

Many changes have been made in the materials and methods employed in cereal seed treatment in the 30 years since copper carbonate, applied with a barrel treater, was the standard procedure.

Copper carbonate dust is still used as a bunticide in some wheat-growing areas. This is partly because some growers are reluctant to change to new and unfamiliar materials, and partly because there is still a fear of danger associated with the handling of the more poisonous mercury dust fungicides.

The introduction of the slurry method of treatment eliminated the dust hazard from seed-treatment operations, especially in commercial seed-treating plants. Workers in these plants objected to the irritation caused by the flying dust involved in treating seed, and also to the discomfort of wearing dust respirators all day long, especially in warm weather.

Slurry treatments, however, do not eliminate the dust problem after the grain has dried, especially when it is handled in bulk. Considerable flying dust is encountered when the treated grain pours from the storage bin into the grower's truck. The use of sticking agents in slurry treating does not seem to eliminate this nuisance.

Some slurry fungicides are being conditioned with an oily additive designed to reduce their "dusting" after the seed dries, but its effectiveness has not yet been fully determined.

Liquid treatments now on the market or under test may be applied to the seed by the "quick" or "short" wet method, without dilution, at rates ranging from 1/2 to 4 liquid ounces per bushel, according to the directions of the different manufacturers. Examples of these are Panogen, Setrete, Pentrete, Tag 331, and Vancide 51. Thorough agitation of the seed is essential after these chemicals have been applied. These fungicides may be applied also in a slurry treater after first diluting them with the proper amount of water. They completely eliminate the dust nuisance both during and after treatment.

Liquid treatments of this type necessarily must be volatile in order to be effective. This suggests the hazard of inhaling fumes from the liquids or from the seed treated with them. This may be reduced by the use of fans and proper ventilation. Mercury treatments in dust form also are volatile, and it is inadvisable to work continuously in closed unventilated buildings containing large amounts of seed treated with these materials.

In some wheat-growing areas of the Pacific Northwest, much of the work of treating seed is done by seed-treating plants. In some localities the growers sell all their wheat to the seed dealer, who selects the best seed of the popular varieties, cleans and treats it, and sells it to the growers. In other areas the growers save a portion of the best seed they raise and take it to the seed dealer or to a cooperative plant, for cleaning, treating, and storing until seeding time. In general, the central seed plants are better equipped than are the growers to do the cleaning and treating because they can afford to install more efficient machinery for that purpose. The cost of custom cleaning and treating ranges from 10 to 15 cents per bushel.

On smaller farms much of the treating is still done with simple home-made treaters, or mobile cleaning and treating outfits that travel from farm to farm. These itinerant outfits invariably use dust fungicides and hence create a dust hazard. The types observed by the writer usually employed a suction fan to protect the workers, especially those bagging the seed. Arny (1) determined by these tests that a fan so used may remove one-half or more of the dust as the seed leaves the mixing chamber. He used the bioassay of Leben and Keitt (2) to test the relative accuracy of 15 dust treaters of three different makes, and 5 slurry treaters of two different makes, in applying Ceresan M to oats at rates ranging from 0.25 to 1 ounce per bushel. He tested four samples from each machine. The average amount of Ceresan M actually applied by the dust machines ranged from .07 to 0.84 ounce per bushel, while that applied by the slurry machines ranged from 0.26 to 0.85 ounce per bushel. These results indicate that slurry treaters are more nearly accurate than dust treaters. Advocates of the liquid seed treatments, applied by the "short" or "quick" wet method, maintain that this method of application is superior to the others in this respect because all of the fungicide that is applied is absorbed by the seed. This form of treatment is now rather widely used in the Midwest.

Cereal disease control in the Southeast presents problems somewhat different from those encountered in the Central United States or in the Pacific Northwest. High average temperatures, relatively high humidity, and mild winters favor seed deterioration, insect infestation, and infestation of the soil with fungi that cause seed-rot, root-rot, and seedling diseases. Prominent among these fungi are species of Helminthosporium, Fusarium, Pythium, and Rhizoctonia.

It is possible that soil treatment as well as seed treatment is needed in this area. In 1948 Dr. C. H. Arndt treated 20 x 20 foot plots with methyl bromide before sowing oats in certain

fields in South Carolina that had produced poor stands and yields in previous years. He reported that in one county the yield of the treated plots was 77 percent greater than that of corresponding untreated plots; and in another county the treatment resulted in a 36 percent increase. These results were obtained in spite of very dry weather shortly before maturity. The stands in the treated and untreated areas were about alike. The differences in yield presumably were due to the heavier yield per culm in the treated areas, because of the elimination of undetermined pests in the soil.

R. W. Earhart, at Gainesville, Florida, treated seed of Southland oats with six different fungicides, including two organic mercurials and four non-mercurials, in the fall of 1951. Different portions of seed were treated with each chemical and held in the laboratory in closed kraft paper bags for 4, 28, and 49 days before sowing. The seed was heavily infested with Helminthosporium avenae and H. sativum. The different seed lots were planted in 4-foot nursery rows with 8 replications, properly randomized. Stand counts were made ten days after emergence. The average percentage of infected plants grown from seed treated with each fungicide and from the untreated seed was obtained by taking a 20-seedling sample from each row to the laboratory for the visual determination of diseased seedlings. An "index of protection" for each treatment of each of the three seed lots was calculated by dividing the average stand from each by the average percentage of infection. These data were subjected to an analysis of variance, and the results are presented in Table 3. The results of this test indicate that seed treatment with Ceresan M and Panogen (either dilute or concentrated) will reduce materially the amount of infection in Southland oat seedlings caused by these seed-borne fungi.

Table 3. Effect of treatment with different fungicides, and of different periods of storage after treatment, on seedling stands and on seedling infection in Southland oats. Gainesville, Florida, 1952.

Seed treatment		Percent stand[a] from seed stored			Average percent infection[b]	Protection index[c] On seed stored			
No.	Fungicide	4 days	28 days	49 days		4 days	28 days	49 days	Average index
1.	Ceresan M	85	97	89	5.7	14.9	17.0	15.6	15.8
2.	Panogen conc.	94	93	89	12.4	7.6	7.5	7.2	7.4
3.	Panogen diluted	87	90	88	11.8	7.4	7.6	7.5	7.5
4.	Vancide 51	81	90	94	46.9	1.7	1.9	2.0	1.9
5.	Arasan	88	98	92	76.8	1.1	1.3	1.2	1.2
6.	Spergon	88	94	84	78.0	1.1	1.2	1.1	1.1
7.	Phygon	89	93	93	34.9	2.6	2.7	2.7	2.7
8.	Untreated	86	98	98	83.9	1.0	1.2	1.2	1.1
L.S.D. 5% level									0.7
L.S.D. 1% level									1.0

[a]Average of 8 replications
[b]Total number of seedlings infected divided by the total number examined
[c]The average percent stand divided by the average percent infection

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U. S. BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING, DIVISION OF CEREAL CROPS AND DISEASES

NOTES ON DWARF BUNT

EVIDENCE OF PATHOGENIC SPECIALIZATION IN DWARF BUNT OF WINTER WHEAT IN THE PACIFIC NORTHWEST

C. S. Holton and O. A. Vogel

A heavy infection of dwarf bunt in Rex wheat occurred near Genesee, Idaho, in the summer of 1952. Attention was first called to this situation by officials of the Idaho Seed Certification Office. Lesser amounts were later seen in two fields of Elmar in the same locality. Previously all varieties, including Rex and Elmar, with the Martin factor for bunt resistance have been highly resistant to dwarf bunt throughout the Pacific Northwest. Consequently the situation mentioned above strongly indicates the presence of a new pathogenic race of dwarf bunt which attacks varieties with the Martin factor.

Previously, only one pathogenic race of Tilletia caries (DC.) Tul. causing dwarf bunt has been recognized. It attacks varieties with the Turkey factor for bunt resistance. The Turkey factor is resistant to all the races of T. caries causing common bunt that are not controlled by the Martin factor. It is not known if the new race of dwarf bunt described here is controlled by the Turkey factor.

Aside from pathogenicity, the apparently new race of dwarf bunt indicated above differs from the long-established more prevalent race by causing less dwarfing of the plants and less stimulation of tillering.

Further evidence that dwarf bunt in the Pacific Northwest is caused by more than one pathogenic race of Tilletia caries is the occurrence of this disease on certain forage grasses in Union County, Oregon, in 1952. Hardison and Corden[1] reported high infestations of Tualatin oat grass in several fields, each with a history of dwarf bunt in wheat. Significant in this connection, though not reported by Hardison and Corden[1], was the occurrence of dwarf bunt on volunteer wheat plants in one of these fields. This indicates either common susceptibility of these two hosts or the presence of two distinct pathogenic races in the same field. In contrast, there was no dwarf bunt in a field of Tualatin oat grass near Worley, Idaho, growing in soil with a history of wheat dwarf bunt. At the same time several volunteer wheat plants in this field had dwarf bunt, indicating in this case differential susceptibility of wheat and Tualatin oat grass. If the dwarf bunt on both oat grass and wheat in Oregon is caused by one race it apparently differs from the dwarf bunt race at Worley, Idaho, by the differential response of Tualatin oat grass.

Though experimental proof is lacking these observations indicate that more than one pathogenic race of Tilletia caries causes dwarf bunt of winter wheat in the Pacific Northwest. This has obvious implications in relation to breeding dwarf-bunt-resistant winter wheat varieties.

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[1]Hardison, John R., and Corden, Malcolm E. A serious outbreak of dwarf bunt in tall oat grass in Oregon. Plant Dis. Reptr. 36:343-344. 1952.

DWARF BUNT IN RYE

R. W. Woodward, C. S. Holton and O. A. Vogel

Several rye plants showing dwarf bunt (Tilletia caries (DC.) Tul.) [= T. brevifaciens G. W. Fischer] were found while making a wheat bunt survey in Utah and southern Colorado. This appears to be the first time that dwarf bunt has been found on rye, although common bunt races of Tilletia caries are known to attack rye. The rye plants ranged from completely smutty with characteristic dwarfing and increased tillering to those with only one or two infected spikes which were about one-half normal height. The sori have the same shape and consistency as those of dwarf bunt of wheat. Also, the spores are like those of dwarf bunt on wheat. The bunted rye plants were in a field of the dwarf-bunt-resistant wheat variety, Wasatch, on the farm of Reese Erickson in northern Sanpete County, Utah. Neighboring fields of Turkey wheat had from 35 to 40 percent dwarf bunt while only a few plants in the field of Wasatch showed infection. These infected plants were growing between the rows of the Wasatch, indicating that they were volunteers of a susceptible variety.

DIVISION OF CEREAL CROPS AND DISEASES, BUREAU OF PLANT INDUSTRY, SOILS, AND AGRICULTURAL ENGINEERING IN COOPERATION WITH UTAH AND WASHINGTON AGRICULTURAL EXPERIMENT STATIONS

INJURY TO GLADIOLI ASSOCIATED WITH THE ROOT MITE, RHIZOGLYPHUS RHIZOPHAGUS (BKS)

J. G. Bald and R. N. Jefferson

In southern California during the last three years gladiolus corms have been found with necrotic symptoms not entirely similar to those normally produced by the common corm-rot organisms. Isolations from affected corms seldom yielded a known pathogen. Most common on the plates were bacteria, Penicillium spp., and Fusarium spp. differing morphologically from F. oxysporum f. gladioli (Massey) Snyder & Hansen, which produces the familiar basal rot and yellows disease of gladiolus. The bacteria have not yet been tested for pathogenicity. Inoculations on gladiolus corms were made with ten single-spore isolates of Fusarium (probably all F. roseum (Lk.) emend. Snyder & Hansen). They had very limited pathogenicity or none when introduced into wounded tissues. The Penicillium isolates were similar to many others obtained from gladiolus corms. Among them were two types with slight evidence of pathogenicity to wounded tissue.

On corms with fresh lesions taken from humid soil or humid storage conditions, a species of mite, Rhizoglyphus rhizophagus (Bks),[1] was generally found associated with the necrotic tissue, particularly around the basal scars.

The root mite is similar in appearance to the bulb mite, R. echinopus F. & R. Neither is easily seen in infested tissues except with a hand lens, but when they occur in numbers on a dark background they are visible to the naked eye as pearly white specks (Fig. 1). The root mite is difficult to find in dry situations; ample moisture is necessary for its development. Damaged corms that have been allowed to become dry may carry very few mites, and this sometimes leads to uncertainty in associating the damage with the root mite.

The primary role of the related bulb mite as a pest of hyacinth bulbs has been questioned (2), and the present study of mite damage to gladioli was begun with this in mind. However, the original observations of damage to gladioli associated with mite infestation were supported by experiments conducted under greenhouse conditions. The symptoms associated with root mite are here described for the benefit of workers in plant pathology.

Under a wide-field microscope incipient stages of two symptom types were seen on the surfaces of affected corms that had been maintained under humid conditions favoring the root mite. One type gave evidence of direct mite damage, the other also of secondary invasion by rotting organisms into tissue damaged by mites.

The uncomplicated mite damage appeared in its simplest form as minute feeding punctures on the corm surface below the husk, with sunken centers and sometimes a rim of swollen cells around them. Swollen cells may have been due to a growth stimulus, presumably from some substance injected by the mites. The feeding occurred when the corms were left in the ground under moist conditions after they had matured, and may in part have taken place while the husks (leaf bases) were still turgid. There were indications that sometimes the mites ate their way along the scales of the husk and penetrated the storage tissues near the junctions of scales and corm.

The end result of this reaction to uncomplicated mite injury was a fully developed gall-like lump up to 2 cm. in diameter, generally towards the base of the corm, in which colonies of mites were living in hollowed-out areas and feeding on the surrounding corm tissue. There were also swollen regions of intermediate size, the smaller ones sometimes apparently free from active stages of the mite, the larger containing small colonies.

There was evidence that organisms capable of growing on the wounded tissue often entered at the earliest stage of mite injury. Tiny spots were found with a central feeding puncture, around which was a small region of necrotic cells surrounded in some instances by a ring of swollen cells. Where rotting had apparently extended rapidly outwards from a central puncture such as this, little or no hyperplastic reaction was evident, and mites could be found feeding in a circular hollow of rotten tissue over which stretched an almost intact external membrane. These pits were capable of being extended to 5 mm. or more in diameter, and to about the same depth (Fig. 1). They later became bounded on the inside by periderm, which stopped the extension of the lesions when the mites were no longer feeding. The membranes covering the lesions might crack, and the contents dry out and escape, leaving pits, generally circular and varying in size and depth.

[1] Determined by H. H. J. Nesbitt from one collection of mites. The stock of corms from which these mites were taken was the source of all colonies used in this work.

FIGURE 1. (left) Field infestation of a gladiolus corm overwintering in the soil: corm lesions containing colonies of the root mite. A few adults are visible as white specks. Cultures from similar lesions yielded no known pathogen. Magnified approximately 3 3/4x.

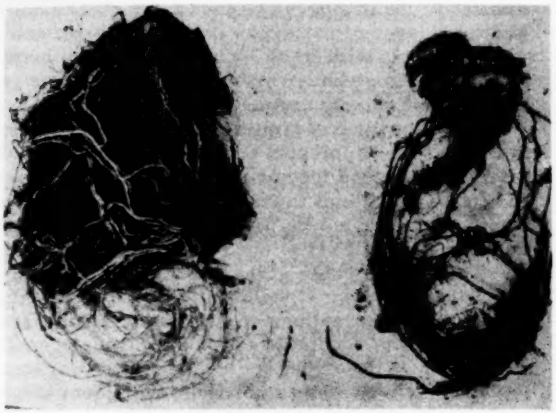

FIGURE 2. (right) Root systems of two gladiolus plants from a greenhouse experiment in pots of sterilized soil. Right, originally healthy plant infested from adjacent infested corm; left, non-infested check.

When a gall-like swelling occurred in the region of infestation, and secondary organisms were involved, there might be a rotten hollow area elevated on a crater-like lump. All intermediate types of lesion between this and a simple pit-like lesion might be present on infested corms. Lesions often became confluent, particularly around the base of the corms adjacent to the remains of the parent corms. Mites colonized this region very readily, probably because it offered them a combination of shelter, humidity, and rotting organic matter.

When, in pot experiments, infestation of clean corms was induced from adjacent infested corms or from the soil, the first and most serious effect was on the roots. Mites ate their way into healthy roots and along them through parenchymatous tissue. In early stages the passages formed in the tissue were free from discoloration, but as the infestation progressed roots became browned, and died back to the region where serious injury had occurred. Within six or eight weeks the greater part of a vigorous root system might be destroyed by a heavy infestation (Fig. 2).

The mites also invaded the sheathing leaf bases, working below ground into the outside leaves. One or more of the short basal leaves might turn brown as the mites consumed the parenchymatous tissues, leaving the vascular strands as the only connections with the corms. Shredding of the leaf bases might proceed until all the outer leaves or whole shoots were prematurely killed. In active infestations the mites might progress upwards between the sheathing leaves to a height of several inches above ground.

In one experiment infested corms from a commercial crop were heat-cured in constant temperature cabinets at fairly high humidities, and later all lots were planted in sterilized soil under uniform conditions in the greenhouse. A count was made of the number of plants becoming so seriously infested by mites that symptoms appeared above ground on the bases of the shoots. This experiment was done before the infesting mites were identified, and there is no certainty that the root mite was involved, although typical symptoms were recorded on the corms and shoots. The numbers of visibly infested shoots produced were at a maximum on corms cured at 85° F., and were at a low figure on corms cured at 95°. From field reports and from this experiment mite damage seems to be favored by moderately high temperatures combined with high humidity. However, in southern California the root mite can continue to

develop actively on corms in moist soil throughout the winter. Evidence is accumulating that the mites, along with a complex of wound-invading organisms, can live over in the soil, and that large populations may build up if a succession of gladiolus crops is planted in the same field. Also the root mite can attack the underground parts of other plant species (1).

Indications are that the root mite, Rhizoglyphus rhizophagus (Bks.), is a serious pest of gladiolus in southern California, partly because of its direct action on roots and corms, partly because of its association with rotting organisms, or even with pathogens such as the organisms causing Fusarium basal rot and yellows, and bacterial scab. That it is basically responsible for much of the damage caused when it infests gladioli has been shown by experiments with insecticides. In preliminary greenhouse trials damage associated with mite infestation has been greatly reduced by insecticidal treatment of infested corms and infested soil. Results of this part of the investigation will be published elsewhere.

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THE FIRST RECORD OF THE BRASSICA-ROOT NEMATODE IN THE UNITED STATES

D. J. Raski

Up to now the Brassica-root nematode, Heterodera cruciferae Franklin, 1945 (2), has been known to occur only in England and Wales (1, 3). This species is closely related to the sugar-beet nematode, H. schachtii, but is distinguished from schachtii by its narrow host range which includes only plants that belong to the family Cruciferae. The sugar-beet nematode has a wide host range covering many plant families including the crucifers. In addition, larvae of cruciferae appear to be stimulated to hatch by excretions from roots of cruciferous plants but not by roots of sugar-beets.

Evidence discovered this year indicates that H. cruciferae has been present in California for many years. It has been found in many of the fields near Half Moon Bay, San Mateo County, where the production of cruciferous crops, especially Brussels sprouts, has been carried on for at least 30 or 40 years. A general survey of the area has not been attempted as yet but the nematode appears to be widespread and well established. A high percentage of the fields that were examined proved to be infested with heavy populations of the nematode.

The discovery of this species was made as the result of attempts to establish experimental field control plots for sugar-beet nematode in the area near Half Moon Bay. A routine check was made on the ability of two populations from separate fields to attack a number of plants, all of which, except the white clover, have been reported as hosts of sugar-beet nematode (4, 5). In these tests, seeds were planted to field soil in four-inch pots and after eight weeks the roots were washed clean and examined for females. The soil of each pot was also screened and examined for males with the following results:

	Nematodes recovered after 8 weeks	
Host Plant	Field A	Field B
Sugar beet	None	None
Curly dock	None	None
Carnation	None	None
White clover	None	None
Sesbania macrocarpa	None	None
Golden Wax Bush Bean	None	None
Garden Pea	None	*
Cabbage	White $\frac{\varphi\varphi}{++}$ Many $\delta\delta$	**
Brussels sprouts	--	White $\frac{\varphi\varphi}{++}$ Many $\delta\delta$

* All the seedlings succumbed to damping off.

**Cabbage seedlings suffered damping off and were replaced with Brussels sprouts.

Another test was made at the same time to get some measure of the population levels of the various fields. In this case three fields (A, B, C) from the Half Moon Bay area were checked against one (D) from Alameda County where table beets had been severely damaged in 1952 by sugar beet nematode. A one-pint sample was secured from each field, allowed to become air-dry, then mixed thoroughly. Four aliquots of 50 gms. each were weighed out from each sample and all the cysts recovered from each aliquot. The cysts were held in small covered dishes in tap water. Two days later small pieces of clean sugar-beet roots were added to each dish. Four weeks later the larvae that had hatched were counted. Only the samples from fields A, B and C were saved and small pieces of roots of Brussels sprouts were added to replace the sugar-beet roots. Counts of larvae that had hatched were made 14 days later. A recapitulation of the results follows:

Source of soil	Total cysts in 4 aliquots (200 gms.)	Larvae hatching in presence of roots of Sugar beets	Brussels sprouts
Field A) Half	79	87	1598
Field B) Moon	163	41	2968
Field C) Bay	229	195	4198
Field D)Alameda Co.	45*	1512*	----

*This count was made from only 2 aliquots of 50 gms. each as two others were lost by accident. There were 52 cysts in the aliquots lost so the count for 4 aliquots would probably have been approximately double that recorded.

These figures indicate a definite response of the larvae from fields A, B and C to excretions from roots of Brussels sprouts and no more response to sugar-beet roots than would be expected in plain tap water. The nematodes from field D were apparently correctly identified as sugar-beet nematode and responded by hatching in the presence of beet roots.

These characteristics of the nematodes from Half Moon Bay are in agreement with the observations of Franklin. In addition, preliminary observations on the morphology of this species conform with the original description of cruciferae. For one thing, according to Franklin, the cysts appear to be slightly smaller and more rounded than are cysts of schachtii. Also, Franklin reports the average larval length as 418 µ. Twenty of the larvae measured here averaged 429 µ (398-460 µ) whereas sugar-beet nematode larvae averaged 469 µ (435-496 µ). The males are also described as slightly smaller (1.2 mm.) than schachtii (1.4 mm.) with a spear about 25 µ whereas in schachtii males it measures 26-33 µ.

Further examination of this material will be made to see if any other morphological differences can be found to exist between these two species. It is probable that identifications of most material will be possible in the laboratory on the basis of the above information. It is doubtful, though, if a positive identification can be made under field conditions and one of the important consequences of the presence of H. cruciferae in California will be the complication of the diagnosis of sugar-beet nematode infestations. Previously the only species of cyst-forming nematode known to occur in the cultivated fields of California has been H. schachtii. Now any diagnosis of a field not under cultivation at the time or of a field planted to crucifers may be questioned as to species. Even where attacks on sugar beets can be demonstrated it is possible that the population that is present may represent a mixture of both these species. Certainly a correct identification will be essential for the effective use of rotation programs in the control of these nematodes.

There is no evidence available at this time as to the importance of H. cruciferae in the production of cruciferous crops. Field experience indicates that attacks by high populations of the sugar-beet nematode can cause severe reduction in the growth of cabbage particularly when grown during the summer months. This has been known to occur near Moss Landing approximately 75 miles south of Half Moon Bay. However, this does not necessarily apply to H. cruciferae and nothing is known regarding the effect of either species on Brussels sprouts at least in California.

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UNUSUAL RECORDS OF PLANT DISEASES

CLADOSPORIUM LEAF SPOT OF PEPPER IN GEORGIA

By J. H. Miller and Jack Taylor

This disease of California Wonder Bell pepper caused by Cladosporium capsici (Marchal & Steyaert) Kovachevsky has apparently not been reported before from this country. It was first collected by Mr. A. B. Winters, Campbell Soup Company, on September 19 in a two-acre field in Union County, Georgia about five miles from Blairsville. The entire field is seriously affected, with some plants completely defoliated, and all showing some leaves with large spots, or the entire underside covered with the dark, velvety mycelial growth. This disease appeared late, and therefore did not affect the fruits to the extent one would expect.

Peppers had not been planted in this field before, although they had been grown in an adjoining field last year. At this time we could not determine where the seed came from.

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CANE BLIGHT OF FORSYTHIA IN MARYLAND

By B. H. Marshall, Jr.

A cane blight on two species of forsythia, F. intermedia and F. suspensa, was found at two locations in University Park, Maryland, in July 1951. At the same time it was also seen on specimens of F. suspensa brought into the laboratory by D. H. Scott from his home near Beltsville, Maryland. A fungus was isolated from the infected canes and identified as Botryosphaeria

FIGURE 1. Healthy and infected shoots of Forsythia intermedia showing cankers on the stem and persistence of the dead leaves.

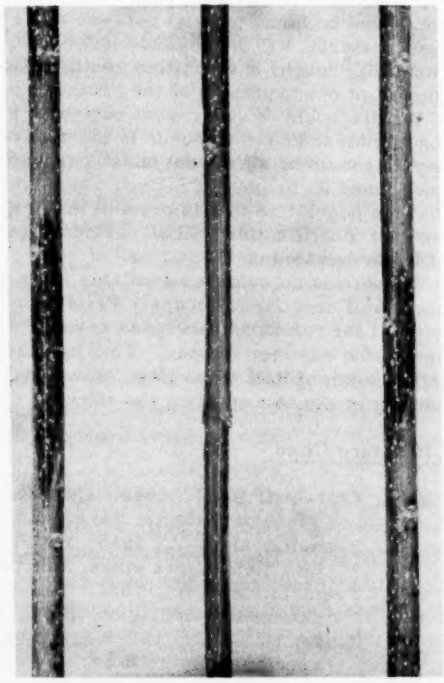

FIGURE 2. Canes of F. intermedia showing dark cankered areas and numerous pycnidia embedded in the dead bark (left and right). Healthy cane in the middle.

Photographs by Otis Greeson.

ribis[1]. This fungus is common both as a saprophyte and as a parasite. It causes canker, dieback, and cane blight of a number of other woody plants including apple, redbud, currant and rose. Although this is believed to be the first report of B. ribis on forsythia it is not the first observation. Laboratory records show that this organism was previously identified[1] on specimens of forsythia collected from a nursery near Rockville, Maryland, in September 1945, by C. L. Lefebvre.

Shrubs infected with B. ribis show girdling and killing of infected canes. The brown, dead leaves above the cane lesions persist conspicuously. Cankers occur at the base of the canes and small black pycnidia are numerous in the dead bark.

Cultures of this organism were used to inoculate canes of F. viridissima growing in the greenhouse in May and August 1952, but no infection resulted.

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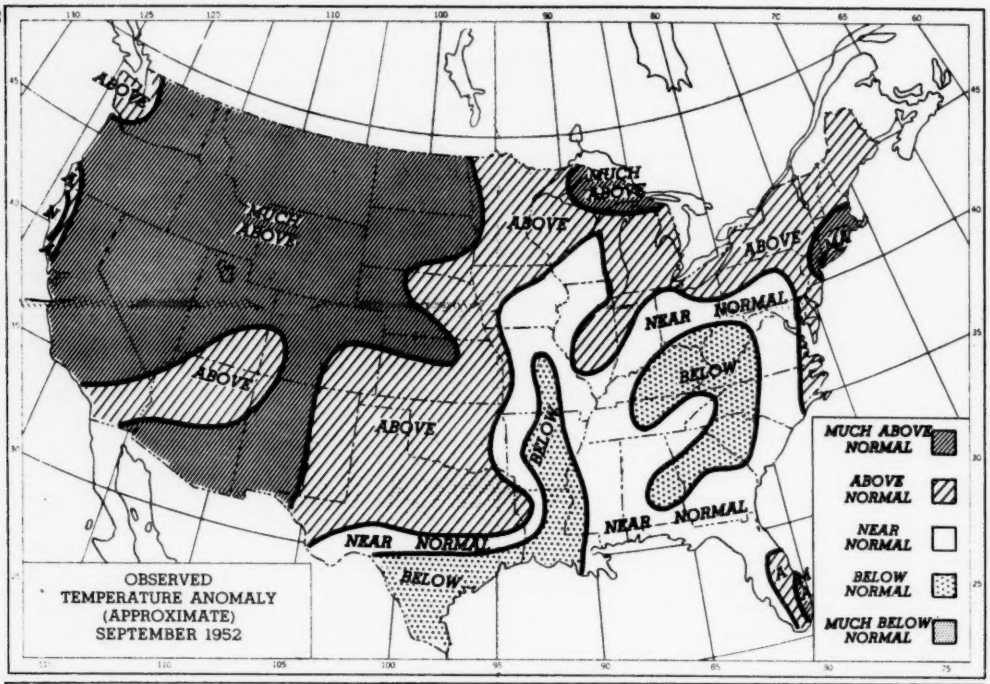
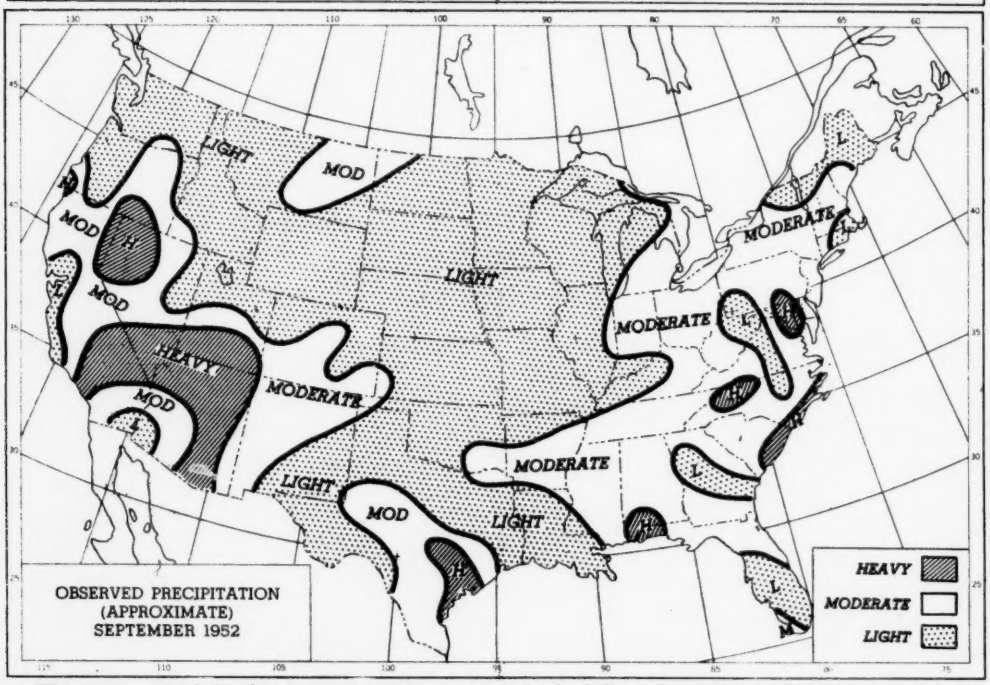
[1]Identification made by John A. Stevenson, Division of Mycology and Disease Survey, Plant Industry Station.





The terms used in the accompanying maps, which define the ranges of temperature and precipitation, are numerical class limits. These are based on a statistical analysis of past records through which is determined the normal frequency of occurrence of temperatures and precipitation at various times of the year for different locations. For temperature the classes above, below, and near normal are so defined that they each normally occur one-fourth of the time; much above and much below normal, one-eighth of the time. Precipitation is depicted in terms of light, moderate, and heavy, each class normally occurring one-third of the time and thereby having equal probability of occurrence. These maps graphically represent only the general trends and give the country's weather picture at a glance. For quantitative studies, where monthly mean temperatures and actual precipitation records are needed for a given time and place, other publications of the Weather Bureau should be consulted. P. R. M.